THE

AMERICAN GEOLOGIST.

A MONTHLY JOURNAL OF GEOLOGY

AND

ALLIED SCIENCES.

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VOLUME IV.

JULY TO DECEMBER.

MINNEAPOLIS, MINN.

1889.

THE SWINBURNE PRINTING COMPANY

CONTENTS.

JULY NUMBER.

AUGUST NUMBER.

SEPTEMBER NUMBER.

OCTOBER NUMBER.

NOVEMBER NUMBER.

DECEMBER NUMBER.

BENJAMIN FRANKLIN SHUMARD.

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VOL. IV. JULY, 1889. No. 1

BENJAMIN FRANKLIN SHUMARD.

In the current literature of geology forty years ago there were few American names that appeared more frequently and stood more honorably than that of Dr. B. F. Shumard of St. Louis. With the exception of that of Dr. D. D. Owen, his was associated with more of what was known of the geology of the country west of the Mississippi than any other. In the carrying out of a purpose to gather together in the GEOLOGIST brief memoirs of the early geologists of the western and particularly of the northwestern part of the country, we are impressed with the record of careful paleontological work which Dr. Shumard accomplished under the constraint of unfavorable circumstances, and with the general correctness of the ideas which he entertained of the geology of the country. His work extended from Minnesota and Oregon to Texas, but was interrupted by the war of the Rebellion. The following sketch is condensed from information furnished chiefly by Dr. A. Litton of St. Louis, and from biographical sketches of Shumard, one by Dr. L. P. Yandell, published in the *Western Journal of Medicine*, Indianapolis, Dec. 1869, and another by Mr. L. Gray. which appeared first in the editorial columns of the "*Missouri Republican*" and subsequently in Vol. XLVIII (2nd ser.) of the *American Journal of Science*. The accompanying portrait is reproduced from a photograph in the possession of Dr. Litton.

Benjamin Franklin Shumard was born Nov. 24, 1820, at Lancaster, Pennsylvania. His father, John Shumard, was a direct descendant of the Huguenots, a man of rare intelligence, culture and moral worth. His mother, the daughter of a distinguished inventor of Philadelphia who was at different times also an author, editor and publisher, and who received high honors in both civil and military life, is described as having a "taste for letters conjoined with sound judgment, deep piety and natural sweetness of disposition."

Thus the childhood and early youth of Dr. Shumard were spent in that best of all training schools, a cultured christian home; and here were laid the foundations of his pure and lofty character.

In 1835 his father removed to Cincinnati and soon after, at the age of 15 the son entered Miami University, Oxford, Ohio. Here he remained three years, an earnest and successful student. At the end of that time and before he had finished his course, his father returned to his native state, taking the son with him. Two years later he entered the Medical College of Philadelphia, but left after one year to accompany his parents to Louisville, Kentucky. Here he continued his medical studies and graduated with distinction from the Medical Institute of Louisville, in 1842. He entered upon the practice of his profession in a small town in Kentucky where he was a stranger to all; and his extreme modesty, scholarly tastes and love for science prevented his making acquaintances or securing much practice. His father said sadly when he returned home discouraged at the end of the year, that he was "afraid Benjamin had so many rocks in his head there was no room left for medicine." His mother sympathized with his love for science and urged him to pursue his investigations and his geological studies. In Prof. Cobb he found a congenial spirit, and together they explored all the localities rich in organic remains in the vicinity of Louisville, and made collections of fossils. In the study of these Dr. Shumard's medical education was an invaluable aid.

When Mr. Edward de Verneuil, in the course of a tour to determine the parallelism of the paleozoic formations of North America with those of Europe, visited Louisville in 1846 he was delighted at finding in Shumard's collections fossils so analogous to many in his own cabinet as to fix beyond doubt

the equivalency of the corresponding formations, and in token of his appreciation of the work of the young scientist he presented him with a copy of his splendid work on the Paleontology of Russia.

Dr. D. D. Owen visited Louisville with M. de Verneuil and soon after appointed Dr. Shumard as assistant on the survey of the northwestern territories. He continued in this work for four years and took a prominent part in the preparation for and contributions to those important earliest government reports, viz: The geology of Wisconsin, Iowa and Minnesota.

During this time, in 1847, he prepared a paper under the title of "Contributions to the Geology of Kentucky," which contained many new facts of observation and is still referred to by those who have occasion to notice the organic remains of Kentucky. This attracted unusual attention, and made his name familiar to geologists in Europe and America.

In 1850 Dr. Shumard accompanied Dr. Evans to assist in a geological reconnaissance of Oregon. He spent eighteen months in this work and prepared the paleontological report. During the year following he was occupied in identifying the fossils collected by his brother in an expedition for exploration in the Red River region under Capts. B. B. Marcy and G. B. McClellan.

In 1853 he was appointed assistant geologist and paleontologist of the Missouri geological survey under Prof. Swallow. He gave his usual diligence and fidelity to this work until called in 1858 by governor Runnels of Texas to take charge of the newly authorized survey of that state.

He entered upon this great work with enthusiasm and in the hope and expectation of being able to carry it forward to its completion. For two years he pursued it industriously and made a reconnoissance of the entire eastern and middle portions of the state. He made the interesting discovery that the geological deposits of Texas are the most complete of any known on the continent of America, ranging from the Archæan up to the latest Tertiary formations. The specimens collected during the continuance of the survey were arranged preparatory to writing his report, when Gen. Houston, who had just been elected governor, removed him from office to make room for one of his political supporters. A short time after, the war of the rebellion broke out, and put an end to geologi-

cal surveys for the time in our country. Dr. Shumard returned to St. Louis and with difficulty succeeded in rescuing his library from Austin after the close of the war. Soon after his return from the Oregon expedition in the autumn of 1852 he married Miss E. M. Allen of Louisville, a lady of rare literary attainments, and of congenial tastes, who had made his home in Austin, as well as in St. Louis, a delightful one. Upon his return to St. Louis in 1861, he resumed the practice of his profession as a means of support for his family. With this stimulus he succeeded in winning not only the support he sought for his family, but position and competence in a profession which had been abandoned for fifteen years. He was elected professor of medicine in the University of Missouri in 1866. After two years of successful work in this field consumption developed. He declined rapidly and died the 14th of April 1869, in the 49th year of his age. His wife and two daughters survived him. At the time of Dr. Shumard's death he was president of the St. Louis Academy of Science, and corresponding member of the Academies of Philadelphia, California, Cincinnati and New Orleans, in America. He was also a corresponding member of the Geological Society of London, the Geological Society of France, the Imperial Geological Society of Vienna and the Imperial Geological Society of Darmstadt.

His labors have attracted the attention of geologists in all countries. The high estimation in which they are held is attested by the constant reference to them in later works that relate to the geology of North America.

LIST OF THE PUBLICATIONS OF B. F, SHUMARD.

1847—Contributions to the geology of Kentucky. *Western Journal of Medicine and Surgery.*

1851—Geological report of local detailed observations in the valleys of the Minnesota, Mississippi and Wisconsin rivers, made in the years 1848 and 1849. *Owen's report on the geology of Wisconsin, Iowa and Minnesota.* p. 481.

—Descriptions of one new genus and twenty-two new species of crinoidea, from the Sub-Carboniferous limestone of Iowa. (Conjointly with Dr. Owen.) Owen's Report, I., Wis. and Minn. p. 587. [First published in the *Jour. Phil. Acad. Sciences*, vol. II, 2nd Ser. p. 57.]

—On the number and distribution of fossil species in the paleozoic rocks of Iowa, Wisconsin and Minnesota (Conjointly with Owen.) *Proc. A. A. A. S.*, 1851, p. 235.

1852—Descriptions of seven new species of Crinoidea from the sub-Carboniferous limestone of Iowa and Illinois. (Conjointly with Owen). *Jour. Phil. Acad. Sciences*, vol. II, 2nd Series. p. 89.

This year he contributed to the report of Marcy & McClellan on the Exploration of the Red river.

1855—Description of a geological section on the Mississippi river from St. Louis to Commerce; and descriptions of new species of organic remains. *Second report Geol. Sur.* Mo. pp. 139, 185.

1856—On some new species of fossils from the Cretaceous of Nebraska territory. Evans & Shumard. *St. Louis Acad. Sci.* vol. I. No. 1. p. 38.

Description of new fossil crinoidea from the paleozoic rocks of the western and southern portions of the United States. *Trans. St. Louis Acad.* vol. I. No. 1.

1857—Discovery of the Permian Formation in New Mexico. *Trans. St. Louis Acad.* vol. I, No. 2.

Description of new fossils from the Tertiary formation of Oregon and Washington territories, and the Cretaceous formation of Vancouver's island, collected by Dr. Evans, *Trans. St. Louis Acad.* vol. 1. No 2, p. 120.

Descriptions of new species of blastoidea from the paleozoic rocks of the western states, with some observations on the structure of the summit of the genus Pentremites. *Trans. St. Louis Acad.* vol. I, No 2, p. 238.

1858—Notice of new fossils from the Permian strata of New Mexico and Texas, collected by Dr. G. G. Shumard. *Trans. St. Louis Acad.* vol. I, No. 2, p. 290.

Notice of fossils from the Permian strata of Texas and New Mexico obtained by the United States expedition under Capt. John Pope for boring artesian wells, with descriptions of new species from those strata and the Coal Measures of the region. *Trans. St. Louis Acad.* vol. I. No. 3, p. 387.

1859—Observations on the geology of St. Genevieve, being an extract from the report made to the Missouri Geological Survey in 1859. *Trans. St. Louis Acad.* vol. I, No. 3, p. 404.

1860—Observations upon the Cretaceous strata of Texas. *Trans. St. Louis Acad.* vol. I, No. 4. p. 582.

Descriptions of new Cretaceous fossils from Texas. *Trans. St. Louis Acad.* vol. I, No. 4. p. 590.

Notice of Meteoric iron from Texas. *Trans. St. Louis Acad.* vol. I, No. 4. p. 622.

Descriptions of five new species of gasteropoda from the Coal Measures and a brachiopod from the Potsdam sandstone of Texas. *Trans. St. Louis Acad.* vol. I, No. 4. p. 624.

Dicotyledonous leaves in Cretaceous strata of Texas. *Trans. St. Louis Acad.* vol. II, No. 1. p. 140.

Vertical section of Silurian strata of Cape Girardeau county, Mo. *Trans. St. Louis Acad.* vol. II, No. 1. p. 156.

Sketch of the life and scientific labors of Dr. John Evans. *Trans. St. Louis Acad.* vol. II, No. 1. p. 162.

1862—New fossils from the primordial zone of Wisconsin and Missouri. *Trans. St. Louis Acad.* vol. II, No. 1. p. 101.

Descriptions of new paleozoic fossils. *Trans. St. Louis Acad.* vol. II, No. 1. p. 108.

Notice of a (supposed) meteorite. *Trans. St. Louis Acad.* vol. II, No. 1, p. 183.

1865—On oil springs in Missouri. *Trans. St. Louis Acad.* vol. II, No. 2, p. 263.

A chronological list of works on the paleozoic echinodermata of North America. *Trans. St. Louis Acad.* vol. II, No. 3. p. 33[illegible]

Catalogue of North American paleozoic echinoderma[illegible] *St. Louis Acad.* vol. II, No. 3. p. 341.

Table of genera and species of echinodermata in the geological formations of North America. *Trans. St. Louis Acad.* vol. II, No. 3. p. 401.

Dr. Shumard's contributions to the report of Dr. Evans on the geology, topography and resources of Oregon has never been published. Dr. Evans died soon after its completion. He was engaged on the work actively for five years. Evans' report was ordered printed by Congress in 1860 but there seems to have been some informality in the execution of the proper order. Shumard closes his sketch of Evans (1861) as follows: "It is earnestly hoped that Congress will, at an early period, make the necessary provision for the printing of this important document, the preparation of which has cost such a large expenditure of labor and money, and which promises to be of the highest value to science and the people for whose benefit the survey was ordered." *Trans. St. Louis Acad.* vol. II, p. 164.

STUDIES IN THE INDIANA NATURAL GAS FIELD.

By FRANK LEVERETT.

The excitement occasioned by the discovery of natural gas in the Trenton limestone at Findlay, Ohio, in 1884, has resulted in such a honey-combing of the strata of Indiana, Ohio, and southern Michigan by deep gas boring as would scarcely have been dreamed of five years ago. More than 250 borings made in Indiana have reached the Trenton limestone, and several have been pushed to still greater depth, some even to the underlying sandstone. It is obvious that the more numerous are these borings, the more complete is our knowledge of the hitherto concealed strata and their products. Minor phases of structure or topography and isolated gas or oil belts which the first few borings failed to reveal, are being brought to light as the borings increase in number, and generalizations made when the borings were few, must in many instances be qualified as they multiply. It is not the aim of this paper to develop theories and principles; its value lies in the fullness of the data collected, and in the compactness of their arrangement which renders comparison easy, thus bringing out their significance in a manner not possible to a loose arrangement. The well-sections here given, so far as they are not assigned to other authorities, were collected incidentally by the writer while making a study of the glacial phenomena in the vicinity of the gas field. Since our study was carried through every township of the area, it afforded excellent opportunity for collecting the records of the gas borings. Lack of time, however, prevented a thorough examination of suits of specimens which in Jour. instances had been preserved. The records of many

of the borings were obtained from members of gas companies in the towns where they were made, and are considered quite trustworthy. Some were obtained from well-drillers. Of about one-half of the borings no records have been preserved, and it was found necessary to rely upon statements made from memory either by well-drillers or by members of gas companies. It was feared that many errors might exist in a compilation of data, of which so large a percentage was acquired in this way but our tabulated sheet fails to discover them,—on the contrary it establishes the general reliability of the sections as reported. In the accompanying tables the divisions are based upon broad differences in structure. It is probable that by an elaborate system of optical and chemical analyses of such suits of specimens as have been preserved a good classification might be made, comparable in the number of groups represented, though perhaps not identical with, the outcropping groups which appear in other states between the horizon of the Devonian shales and that of the Trenton limestone. We find that such a careful analysis as is called for has not been made. A few suits of specimens which have been secured by Dr. A. J. Phinney of the U. S. Geol. Survey, have been sufficiently examined to satisfy him that several groups not hitherto included in the reports of the Indiana Geological Survey are brought to light by these well-drillings. The present status of knowledge upon this subject is such, however, as to compel us to ignore these minor divisions of the "upper limestone" and "lower shales" and recognize but three terranes above the Trenton limestone, viz.: the "upper shales," the "upper limestones" and the "lower shales."

Boundaries of the Devonian shales.—The gas borings have demonstrated the fact that in north-eastern Indiana the Devonian, or upper shales of our table, extend south scarcely far enough to cover DeKalb, Noble, Kosciusko and Marshall counties, for at Garrett, Columbia City, Larwill, North Manchester and Rochester the upper rock is the limestone which, farther north, underlies the shales. In western Indiana they are found to lie entirely west of Logansport, Frankfort, Sheridan and Indianapolis; but south of the latitude of Indianapolis they extend farther east, being struck at Greenwood, Franklin and Edinburgh in Johnson county.

TABLE OF GAS BORINGS IN INDIANA.—By FRANK LEVERETT.

Location.	Altitude A. T.	Rock Surface. A. T.	Drift.	Upper Shales.	Upper limest'nes	Lower Shales.	Altitude of Trenton B. T.	Remarks.
	Feet	Feet	Feet	Feet	Feet	Feet	Feet	
Elkhart Co., Elkhart,	726	621	105	445	?	?	?	The boring was not carried to [the Trenton.
" " Goshen	789	624	165	308	787	560	1081	No gas.
Marshall Co. Plymouth	780	538	242	64		(1019)	545	" "
Kosciusko Co., Warsaw	824	577	247	?	?	?	556	" "
Noble Co., Albion (P)	950	575	375	65	900	535	920	" "
" " Kendallville	974	489	485	215	600	620	946	" "
DeKalb Co., Waterloo	890	525	365	145	980	?	?	
" " Butler	863	476	387	108	1064	522	1218	" "
" " Auburn	872	590	282	120	958	578	1061	Gas, estimated at 1,500,000 cubic [feet per day.
" " Garrett	900	582	318	Wanting	1000	594	912	No gas.
Allen Co., Ft. Wayne	776	670	106	"	764	537	631	" "
Whitley Co., Columbia City	816	592	224	"	....	(1186)	594	" "
" " Larwill	970	605	365	"	565	512	572	" "
Wabash Co.. North Manchester	775	500	274	"	....	(926)	425	" "
" " LaFontaine. (P)	795	495	300	"	175	425	105	Good gas well.
" " Somerset	est 720	617	103	"	....	(720)	103	" " "
" " " 2½ m. s. e. of	" 850	668	182	"	250	522	100	Gas in small amount.
Miami Co., Peru	655	655	Wanting	"	....	(915)	260	No gas.
" " " 9 m. s. e. of	800	740	60	"	....	(914)	154	Gas in small amount.
" " Bunker Hill	800	732	68	"	495	422	186	No gas.
" " Amboy	813	778	35	"	...	(872)	94	Good gas wells.
Fulton Co., Rochester	798	533-643	155-245	"	530?	385?	363	No gas.
Cass Co., Galveston	776	735	41	"	400	489	154	" "
" " Logansport	596	596	Wanting	"	544	396	344	" "
" " Royal Center	735	626	109	"	....	(816)	190	Oil.
White Co., Monticello, (P.)	675	470	205	"	....	(805)	335	No gas.
Carroll Co., Delphi	550-615	550-615	0	"	555-570	313-360	262-365	"
" " Flora	750est	614	136	"	520	306	212	" "
Clinton Co., Frankfort	855	577	278	"	390	419	232	" "
" " " 5 m. east of	905	605	300	"	360	445	200	" "
" " circleville	924	628	296	"	350	432	154	" "
" " Kirklin	956	704	252	"	337	500	188	" "
Tipton Co., Kempton	920	614-677	243-306	"	293-344	424-489	106	Good gas wells
" " Tipton	858	719	139	"	326	532	139	No gas.
" " " No. 2	865	713	152	"	467	396	141	" "
" " Near Hobbs	870	767	103	"	332	540	105	Good gas well.
" " " "	870	736	134	"	330	529¼	105	" " "
" " Sharpsville	860est.	790	70	"	400	485	96	" " "
" " Windfall	850 "	778	72	"	300	600	120	" " "
Howard Co., Russiaville	860	707	158	"	...	(842)	185	No gas.

Howard Co., Fairfield	850est.	808	47	Wanting	385	500	87	Good gas well.
" " Kokomo	820	815	5	"	400	498	83	" " "
" " " 11 m. s. e. Barrett's	840est.	742	98	"	280	551	94	" " "
" " " 7 m. s. e. of Brobst	830est.	715	115	"	325	482	92	" " "
" " Greentown	830	745	85	"	...	(845)	100	" " "
Grant Co., Point Isabel	860est.	837½	22½	"	...	(892)	55	" " "
" " Sims Station	865	815	45	"	345	532	62	" " "
" " Swayzee	860	838	22	"	...	(890)	52	" " "
" " Fairmount	893	875	18	"		(922)	29	" " "
" " Jonesboro	835	673	162	"	...	(750)	77	Good gas well but weaker than at [Marion or Fairmount
" " Marion	814–850	650–794	20–200	"	100–280	500	40	15 good gas wells.
" " VanBuren	860	860–766	94–170	"	211–287	600	110	Oil and gas small amt.
Blackford Co., Montpelier	845–855	845	0–10	"	290–320	640–675	115–120	Oil and gas.
" " Hartford City	910	777–826	84–188	"	220–236	592–621	31–35	Gas in large amount.
" " Mill Grove	945	802	143	"	...	(796)	6 x	" " " "
Wells Co., Bluffton...(T.)	820	820	0	"	350	700	230	No gas,
Adams Co., Geneva	845	455	390	"	Wanting	615	150	" "
Jay Co., Briant	950	838	112	"	138	750	50	" "
" " Portland	900	842	58	"	192	740	90	Gas, weak wells
" " Cormo	950	870	80	"	200	695	25	" " "
" " Red Key	978	905	73	"	162	747	4	Good gas well.
" " Camden	880est.	839	41	"	40	848	49	" " "
" " Dunkirk	959	886–897	62–73	"	228	636	33 x	" " "
Randolph Co Union City (P)	1079	981	98	"	227	830	76	Gas.
" " Winchester "	1081	934	147	"	110	800	24 x	Weak wells.
Wayne Co., Richmond "	969	964	5	"	Wanting	900	64 x	" "
" " Cambridge City "	982	886	96	"	23	684	176 x	" "
Henry Co., New Castle "	995	615	380	"	Wanting	490	125 x	" "
" " Knightstown "	935	854–869	66–81	"	93–115	642–665	112 x	Good gas well
Delaware Co. Muncie "	948–970	885–948	0–85	"	225–265	650	37–70 x	" " "
" " Eaton (T)	913	913	0	"	200	690	23 x	" " "
" " Selma	1005	915	90	"	213	695	7 x	" " "
" " Daleville	910	825	85	"	280	505	40 x	" " "
Madison Co., Summitville	890	780	110	"	210	585	15	" " "
" " Alexandria	857–872	829–850	22–28	"	360	305	15–33	" " "
" " Elwood	850–858	750–794	56–108	"	317–391	484–510	77–81	" " "
" " AndersonCity	820–900	656–804	16–194	"	110–240	520	36–48x	" " "
" " Pendleton	845	840	5	"	251	605	16	" " "
" " "	865	777	90	"	258	528	10	" " "
" " Huntsville	840	820	20	"	220	615	15	" " "
" " Markleville	950	803	147	"	203	600	0	" " "
Hancock Co., McCords	854	668	186	"	177	543	52	" " "
Hamilton Co., Clarksville	820–840est.	758–824	6–82	"	260–332	504–512	6–12	" " "
" " Noblesville	750	717	33	"	282	506	71	" " "
" " " 1½ m. n (at Granger	775	599	176	"	164	523	88	" " "
" " " 2 m. east...Wells.)	800	720	80	"	249	515	45	" " "

TABLE OF GAS BORINGS IN INDIANA.—Continued.

Location.	Altitude. A. T.	Rock Surface. A. T.	Drift.	Upper Shales.	Upper limestone	Lower Shales.	Altitude of Trenton B. T.	Remarks.
	Feet	Feet	Feet	Feet	Feet	Feet	Feet	
Hamilton Co., Cicero	840 est.	570–699	141–270	Wanting	. .	(827)	134	Good gas wells.
" " Arcadia...............	830 "	700	130	"	....	(833)	133	" " "
" " Atlanta..	840 "	520	320	"	....	(645)	125	" " "
" " Sheridan	980	747	238	"	377	416	46	" " "
" " Jolietville	930 "	730	200est.	"	....	(830)	90	Weak gas well
" " Eagletown...........	980	730	200	"	....	(790)	60	" " "
" " Westfield	930	710	220	"	..	(790)	80	No gas.
" " " 3 m. s. e. ...	850	755	95	"	292	536	83	Good gas well.
" " Carmel....	860	764	96	"	374	478	88	" " "
" " Fisher Station.......	795est.	685	110	"		(810)	125	" " "
Marion Co., Oakland	820	589	231	"	111	688	210	" " "
" " Johnson nr. Fall Ck.	770	615	155	"	185	520	90	" " "
" " Kimberlin ... "	777	621	156	"	207	508	99	" " "
" " Rambo .... "	777	600	177	"	206	499	95	Weak gas well.
" " Manseur ..... "	770	542	228	"	126	516	100	" " "
" " Smart's ...... "	827	637	190	"	212	548	123	Good gas well.
" " Speese's ...... "	827	686	141	"	250	552	110	" " "
" " Wolfe's .... "	784	624	160	"	250	562	188	No gas.
" " Lawrence............	885	697	188	"	267	555	125	" "
" " Brightwood.	804	614	190	"	220	541	147	" "
" " Broad Ripple........	755	706	49	"	291	523	108	Good gas well.
" " Indianap'lis(T).	700–720	600–640	80–118	"		(780–820)	180	No gas.
Boone Co., Zionsville	825	660	165	"	315	522	177	" "
" " Lebanon	925	583	342	108	267	395	295	" "
" " Thornton..........	845	770	75		(675)	450	355	" "
Hendricks Co., Danville..........	910	750	160	510	355	403	518	" "
" " Plainfield............	742	652	90	253	382	450	433	" "
Morgan Co., Martinsville.........	600	513	87	441	428	427	770	" "
Johnson Co., Greenwood	820	610	210	90	280	650	220	" "
" " Franklin......	740	570	170	34	290	557	302	" "
Rush Co., Rushville.. (P)......	996	948	48	Wanting	72	718	158 x	Gas in small amount.
Decatur Co., Greensburg "	920	910	10	"	70	747	98 x	Weak gas wells.
Fayette Co., Connersville "	837	752	85	"	Wanting	625	127 x	Gas in small amount.
Franklin Co., Brookville...."	575	418	157	"	"	248	175 x	Weak gas wells.
Dearborn Co. Lawrenceb'g "	477	?	Wanting	"	"	325	152 x	

Well records marked "T" were copied from Thompson's Indiana Geological Report for 1885-6.
Well records marked "P" were reported by Dr. A. J. Phinney, of Muncie, Ind.
Figures marked x indicate above tide.
Figures in parenthesis represent combined thickness of two terranes.

TABLE OF GAS BORINGS IN OHIO.—Reduced from Volume VI, Geology of Ohio.

Location.	Altitude. A. T.	Rock Surface. A. T.	Drift.	Upper Shales.	Upper limestone	Lower Shales.	Altitude of Trenton B. T.	Remarks.
	Feet	Feet	Feet	Feet	Feet	Feet	Feet	
Williams Co., Bryan No. 1	750	596	154	157	1009	665	1240	Shale gas.
" " " " 2	750	596	146	114	1080	648	1238	Weak flow Tren. gas.
" " " " 3	?	?	176	88	1040	635	?	" " " "
Fulton Co., Delta	?	?	115	203	1132	?	?	Shale gas.
" " Wauseon	768	612	156	194	1139	645	1367	Gas in small amt.
Lucas Co., Perrysburgh,	605	?	?	Wanting	492	813	700	Unproductive.
" " Waterville	650	?	?	"	?	?	475	Weak gas well.
" " Toledo	598	488	110	"	454	834	800	Gas in small amt.
" " Air Line Junc.	615	495	120	"	620	685	800	Unproductive.
Ottawa Co.. Sandusky	585	575	10	"	1050	1150	1625	"
Sandusky Co. Fremont	600	600	0	"	360	968	728	Weak gas wells, mainly from Clinton.
Seneca Co., Fostoria	782	780	1½	"	808	946	471	Gas in small amt.
" " Tiffin No. 1	744	744	0	"	560	930	746	Weak gas wells.
Wood Co., Weston No. 1	666	590	70	"	642	833	884	Oil and water.
" " " No. 2	666	596	70	"	620	?	?	
" " Bowling Green,	703	703	0	"	305	790	392–410	Gas.
" " No. Baltimore,	739	676	43	"	441	706	451	Oil and gas.
" " " "	730	?	?	"	?	?	447	Gas, oil and water.
" " " "	730	714	16	"	270	818	380	Good gas well.
" " Bairdstown	750	?	?	"	250	814	315	" " "
" " Simons' Well, Sec. 29, [Bloom. Twp	740	740	0	"	?	(1041)	301	Very strong gas well
" " Rocky Ford	730	669	61	"	369	724	424	Water.
" " Bloomdale	755	739	16	"	274	745	310	Good gas well.
" " Sec. 14, Henry Twp.	730	730	0	"	400	760	430	Very strong oil wells
" " Eastern " "	710–730	?	?	"	about	(1150)	430–440	Fifty good oil wells.
" " Bradner,	693	673	20	"	302	880	529	Oil in small amt.
Henry Co., Napoleon,	666	618	48	86	966	660	1114	Gas in small amt.
" " Deshler,	720	649	71	Wanting	710	700	765	
Defiance Co., Hicksville	762	634	128	4	930	624	1024	Oil and water.
" " Defiance	695	677	18	60	962	630	975	Gas and oil.‡
VanWert Co. VanWert	786	754	32	"	388	800	434	Gas and oil.‡
" " Delphos	775	770	5	"	420	808	453	Unproductive.
Putnam Co., Ottawa No. 1	728	633	95	"	497	718	602	Oil in small amt.
" " " No. 2	728	678	50	"	530	734	586	Gas and oil.‡
" " Columbus G've	752	735	17	"	470	791	526	Oil in small amt.
" " Kalida	725	710	15	"	585	701	576	Oil and gas.‡
Allen Co., Lima	850–900		8–100	"	350–400	840–850	875–433	Oil, water and gas.¶
" " Beaver Dam	864						445	Oil and water.
" " Bluffton	886	831	5	"	425	867	460	Gas, oil and water.

TABLE OF GAS BORINGS IN OHIO.—Continued.

Location		Altitude. A. T.	Rock Surface. A. T.	Drift.	Upper Shales.	Upper limestone	Lower Shales.	Altitude of Trenton B. T.	Remarks.
		Feet	Feet	Feet	Feet	Feet	Feet	Feet	
Allen Co.	Westminster....	1000			Wanting			368	Unproductive.
" "	West Newton	1046						394	"
Hancock Co.	Findlay	782	77	8	"	275	809	300	Gas and oil.
" "	"	771–788		5–25				306–489	General section of about 30 good [oil or gas wells.
" "	Arcadia	806	751	55	"	290	831	370	Weak gas well,
" "	Rawson	821						516	Water.
" "	Cannonsburg	850						450	Weak flow oil & gas.
" "	Arlington	860				387	905	432	Unproductive.
Wyandotte "	Up'r Sandusky.......	828			"			490	"
" "	Whartonsburg.......	900	852	48	"	183	1144	425	"
" "	Carey				"	322	1002	513	Weak gas wells.
Marion Co.,	Marion..............	970	952	18	"	615	1045	708	Unproductive.
Hardin Co.,	Kenton	990	966	24	"	376	1125	560	"
" "	near Patterson	952	948	4	"	196	1027	275	"
" "	Forest	938	869	69	"	192	?	432	"
Auglaise Co.	Wapakoneta	887	791	96–158	"	?	947	348	"
" "	Ste. Mary's....	883	762	121	"	194	880	313	Oil and gas in small amount.
Mercer Co.,	Celina	875	805	70	"	230	810	235	Unproductive.
" "	Sec. 24 Frkln tp......	?	?	110	"	160	860	?	Strong gas well.
" "	St. Henry No. 1	950	763	187	"	110	859	200	" " "
" "	" No. 2	934	800	184	"	187	819	200	" " "
" "	Fort Recovery	?	?	145	"	75	832	?	Gas pocket in shale.
Darke Co.,	Greenville	1055	866	89	"	?	?	81	Unproductive.
" "	near Union City......	1124	1020	104	"	180	864	40	"
" "	Arcanum	1050	?	?	"	?	?	100	Good gas well.
" "	New Madison........	1110	?	?	"	?	?	40	Unproductive.
Shelby Co.,	Sidney No. 1.........	936	936	0	"	?	?	269	Shale gas.
" "	" " 2.........	938	938	0	"	250	955	267	" "
" "	" " 3.........	988	898	90	"	?	?	267	" "
Miami Co.,	Piqua................	868		Thin Sheet	"	100	1085	307	Gas and oil in small amount.
" "	Troy.......	860	727	133	"	Wanting	897	170	Water.
" "	Tippecanoe Cy	845		?	"			180	
Logan Co.,	Bellefontaine........	1190	1040	150	"	479	905	350	Unproductive.
" "	Belle Center.........		?	41	"	300	970	?	Gas in small amt,
" "	Huntsville.....	1115	1048	67	"	318	1015	285	Shale gas.
" "	DeGraff	1090	?	?	"	?	?	280–300	Weak gas well.
Champaign "	Mechanicsburg......	1058	778	280	"	?	?	397	Unproductive.
" "	Urbana	1047	892	155	"	148	1038	308	Gas in small amt.
" "	"	1008	870	138	"	122	1062	304	unproductive.

Campaign Co., St. Paris	1238	?	530	Wanting				
" " "	1238	868	370	"	Wanting	?	?	
Union Co., Magnetic Sp'gs	?	?	40	"	354	1206	?	Water.
" " Marysville	?	?	106	"	374	1184	?	Unproductive.
Madison Co., London	1035	880	155	"	315	1115	550	"
Clarke Co., Springfield	950	950	0	"	100	1040	190	Shale gas.
Preble Co., Eaton	1030	?	?	"	40	990	Sea level.	Unproductive.
" " Camden	?	?	181	"	Wanting	659	?	
Montgomery Co., Dayton	825	825	0	"	"	940	115	Unproductive.
" Miamisburg	?	?	187	"	"	520	?	Shale gas.
Greene Co., Xenia	926	832	95	"	"	936	114	" "
" " Osborne	820	613	207	"	"	783	170	" "
" " Spring Valley	750–775	?	?	"	?	?	100–125	Unproductive.
Fayette Co., Washington	965	895	70	"	98	1182	885	Unproductive.
Pickaway Co. Circleville	?	?	140	160				Incomplete.
Ross Co., Chillicothe	?	?	?	400				"
Butler Co., Hamilton	62[illegible]	420	200	Wanting	Wanting	350	70 x	Shale gas.
" " " No. 2	620	406	214					Incomplete.
" " Oxford	900	860	40	"	"	790	70 "	Unproductive.
" " Middletown	667	657	10	"	130	490	87 "	Shale gas.
Warren Co., near Lebanon	700	444	256		?	?	88 "	" "
Clinton Co., Wilmington	?	?	84		23	850	? "	Unproductive.
" " New Vienna	1126	?	?	"	195	1026	100 "	"

Devonian limestone.—Judging from outcrops of Devonian limestone in Hamilton and southeastern Madison county, at Logansport and elsewhere, we conclude that much of Marion, Hamilton, Tipton, Clinton, Howard, Cass and Carroll counties have a limestone of this age as the surface rock. Examination of a few samples from borings in these counties confirms us in this opinion, but since we have no better evidence than that derived from a hurried inspection of the color and texture of rock drillings in the places where no outcrops occur, it seems unwise to attempt a complete separation from the underlying Upper Silurian limestone.

Upper Silurian limestone—Over eastern Indiana the prevailing surface rock is the Niagara limestone. Here and there it has been entirely removed by preglacial erosion, and in southeastern Indiana it is entirely wanting, the Lower Silurian shales forming the surface rock. The Niagara probably had, previous to its erosion, a general thickness of 300-400 feet. It is thicker near the west line of its outcrop where the De-

vonian limestones set in, than it is near the east line of the state. How much of this difference is due to original inequality and how much to erosion has not been determined.

Variation in thickness of "lower shales."—The "lower shales" become gradually thicker from west to east both in Indiana and Ohio. By reference to the accompanying tables it will be seen that along the western portion of the district which they cover, the thickness in Cass and Carroll counties falls below 400 feet, and in Clinton, Boone, Hendricks and Morgan counties their usual thickness lies between 400 and 500 feet. Passing eastward from these counties we find a gradual increase, the thickness in the eastern range of counties, (south of the Wabash river,) being from 700 to 900 feet. Continuing eastward into Ohio, a similar increase is noted, the thickness in Madison and Union counties being over 1100 feet, as is shown by Prof. Orton's report. (Geology of Ohio, Vol. VI). [1] A belt taken in the same manner across the northern portions of Indiana and Ohio shows nearly as great an increase in the thickness of these shales, but it lies mainly in Ohio, there being at Goshen, Indiana, 560 feet and at Bryan, Ohio, but 650 feet. In Ottawa, Seneca, Sandusky, Marion and Wyandotte counties, however, the thickness averages more than 1,000 feet. This thickening of the shales toward the east was not known previous to the gas explorations and consequently a mistaken idea has prevailed as to the trend of the main axis of the Cincinnati anticlinal, north from the Ohio river. Its main axis was supposed to pass east of north past the western end of lake Erie into Canada, through this belt of thick shale; but it is now known that the main axis passes northwest into Indiana, as we shall presently show. There is, however, a minor axis in western Ohio along the line formerly considered to be that of the main axis, the value of which is shown in the table of altitudes of the Trenton limestone.

Cincinnati anticlinal.—The column of the table devoted to the altitude of the Trenton brings out the main features and also some of the minor phases of the topography of this interesting formation.

[1] The table which pertains to the Ohio district was compiled from data given in the volume referred to, and is inserted for purposes of comparison.

A broad, elevated, nearly level-topped tract, to which Prof. Orton has given the names "arrested anticlinal" and "terrace,"[1] enters Indiana in its southeastern corner and passes northwest with a gradual decline in altitude to southern Wabash and Miami counties and central Howard county. It underlies the greater part of the following counties: Dearborn, Franklin Rush, Fayette, Union, Wayne, Henry, Hancock, Hamilton, Madison, Delaware, western Randolph, western Jay, Blackford, Grant, Tipton, Howard, southern Miami and southern Wabash.

The highest ascertained points which have come to the writer's knowledge are at Brookville and Cambridge City—175 and 176 feet A. T.; and the lowest are in Tipton and Howard counties, near the northwestern end of this elevated table, where several borings show the Trenton to be 100-140 feet below tide. That the line of strike lies in a S.E.—N. W. direction is evident from the fact that any line of the length, for instance, of the distance from Cambridge City to Kokomo (about 75 miles,) taken in any other direction from Cambridge City than a general S. E. or N. W. course, would show a much greater descent. For example, at Bluffton, 75 miles north from Cambridge City, the altitude is 230 feet below tide, and at Danville, some 75-80 miles west, 518 feet below tide, while at Kokomo it is only 83 feet below tide. Amboy, in Miami county, and La Fontaine in Wabash county, each about 75 miles from Cambridge City, show but little more descent than Kokomo, thus demonstrating that the level-topped phase of the Trenton here occupies a breadth of about 30 miles. West from Kokomo or east from La Fontaine a rapid descent soon begins, as the table shows.

In Miami and Cass counties the Trenton makes a rapid descent toward the northwest as is shown by borings along the Wabash river, its altitude at Peru being 260 feet, and at Logansport 344 feet below tide. At Royal Center, in northern Cass county, the Trenton stands markedly higher than at Logansport, its altitude being but 190 feet below tide.

East-to-west axis of upheaval.—There is probably an axis of upheaval running from Royal Center west to Monon and thence to Kentland, Indiana. No borings of which we have the record have struck the Trenton along this line, but the

[1] Geology of Ohio, VOL. VI, p. 94.

rock out-crops and deep borings to the north and south indicate that such an axis exists. At Monon the Niagara limestone out-crops at an altitude 675 feet A. T. If we assume that the Niagara has here its known maximum thickness, 400 feet, and that the lower shales have a thickness of 350 feet,—which is a liberal allowance since they are but 313 feet in one of the borings at Delphi, and since borings in Illinois, cited on a subsequent page, as well as those given in the tables, show that the shales decrease in thickness toward the west,—the Trenton should be struck at Monon at about 75 feet below tide.

Three miles east of Kentland is an out-crop of limestone which is thought by S. S. Gorby, Esq., of the Indiana Geological Survey, [1] to be Niagara, but which may possibly be a Lower Silurian limestone. If we consider it Niagara and give it the known maximum thickness of this formation, 400 feet, and assume that the lower shales are 300 feet in thickness, the Trenton would be about 25 feet above tide at this point.

From Kentland the axis probably bears northwest. We find evidence of an anticlinal north of the Kankakee river in the borings made at Chicago, Joliet and Kankakee. In the well at the Union stock-yards in Chicago the Trenton is struck at 93 feet A. T. At the state penitentiary near Joliet the bottom of the lower shales is reached at 175 feet A. T. Here a rock described as a "sharp sand rock" is struck. We think it probable that this is Trenton limestone, for we have frequently tested rock drillings pronounced by the well drillers sandstone and found them to be granular limestone. A boring near Kankakee reaches the bottom of the lower shales and enters what is probably Trenton at 17 feet below tide. There are indications that the crest of the anticlinal is south of Joliet. One and a half miles west of Manteno a prominent ridge of Niagara is exposed at an altitude of about 750 feet, A. T. The Niagara at Joliet is 355 feet, and at the Kankakee boring is 388 feet in thickness. The lower shales at Joliet are 110 feet, and at the Kankakee boring 213 feet in thickness. Manteno is about 20 miles south of the Joliet and 15 miles north of the Kankakee boring. If we assume a uniform increase in the thickness of the limestone and shales toward the south from Joliet the former would be 375 feet and the latter about 170 feet, and the combined thickness 545 feet. Deducting this from the altitude of the rock

[1] See Geological Report of Indiana. 1885-6. pp. 236-7.

out-crop we have 205 feet A. T., as the altitude of the Trenton at the Manteno ridge.

The eastern-most out-crop of the Trenton in northern Illinois is the one four miles northeast of Morris, in Grundy county. The crest of the anticlinal is probably denoted by this outcrop at an altitude about 550 feet A. T. A few miles west from this point is the southern end of a more prominent axis of upheaval. This and similar axes in Illinois are discussed by Prof. Worthen.[1] Concerning the one referred to this statement is made: "It enters the state in Stephenson county, intersects Rock river at Grand de Tour and the Illinois at Split Rock between LaSalle and Utica, bringing the St. Peter's sandstone to the surface on Rock river and the Lower Magnesian limestone on the Illinois." Its general trend is N. N. W. to S. S. E. How far south of the Illinois it extends he did not determine. The continuation of this axis to the north west across the lead region of Wisconsin is discussed by Prof. Chamberlin in connection with the prominent flexure axes of that state.[2]

The east-to-west axis whose probable distribution has been given, apparently connects the Cincinnati anticlinal with the upheaval in northern Illinois and southwestern Wisconsin, and thus introduces a new feature into the dynamics of the Mississippi basin. The prominence of this axis above the region north of it has been shown by borings in Porter and LaPorte counties, Indiana, which strike the Trenton at 400—600 feet below tide, and above the region south of it by a boring at Terre Haute, 2400 feet in depth, which does not reach the bottom of the Niagara limestone, and by many borings in the coal-fields of eastern and central Illinois, records of which occur in the geological reports of that state, which are still in coal measure strata some distance below sea-level.

Distribution of natural gas.—The majority of the strong gas wells of Indiana lie within the boundaries of the elevated portion of the Cincinnati anticlinal. The limits of the gas field may be roughly outlined by lines connecting the following towns: Greenfield, Hancock county, Broad Ripple, Marion county, Joliet and Sheridan, Hamilton county, Kempton, Tipton county, Kokomo, Howard county, Amboy, Miami county, Somerset and La Fountaine, Wabash county, VanBuren, Grant

[1] Geology of Illinois; vol. I. pp. 4-7.
[2] Geology of Wisconsin; vol. IV. pp. 422-438.

county, Montpelier, Blackford county, Camden and Portland, Jay county. On the north and west the gas fails near the line where the limestone begins a rapid descent. Where the surface of the Trenton is 100–120 feet below tide it is unusually saturated with water. The question of altitude is therefore the all-important one on the north and west borders of the gas field. At the southeast the limits of the gas field are less clearly defined than in other directions. Here the failure of gas is not due to a decrease in the altitude of the Trenton and consequent swamping by salt water; on the contrary the altitude is greater as a rule than in the productive district. It is due to a change in the texture of the gas yielding rock. Prof. Orton discovered this fact on the southern borders of the Ohio gas field.[1] He found a granular, porous, dolomitic limestone containing but a small amount of insoluble material to characterize the productive gas field, while a less porous limestone containing but little carbonate of magnesia, but having much insoluble material, characterizes the unproductive portion of the Cincinnati anticlinal. It is the physical structure of the rock, not its chemical composition, which determines its capacity to contain gas. As might be expected, this change in texture has an irregular border, and is more complete at some points than at others, consequently it is difficult to define the limits of the gasfield on the southeast. The strong gas wells lie north of a line connecting Greenfield, Muncie and Red Key, Jay county. Weak wells are found at various points in the southeastern counties of Indiana.

Strength of wells.—Many of those classed in the tables as good gas wells yield less than 1,000,000 cu. ft. per day, as their capacity to furnish fuel clearly shows. Not infrequently wells are found to yield when piped for fuel no more than half the amount indicated by the gauge. There are within the territory, however, wells which yield not less than 7,000,000 cu. ft. per day. Such are the "Jumbo" well at Fairmount, in Grant county, and the "Granger"[6] wells near Noblesville, in Hamilton county. There is often a great difference in strength displayed by wells in close proximity, the variation being probably due to difference in the texture of the rock.

Minor anticlinal.—Near the line of Tipton and Clinton

[1] Geology of Ohio; vol. VI, pp.103–105.

counties there is evidence of a minor anticlinal beneath which gas is found, while it is wanting in a narrow belt on the east between this productive area and the main gas field. Tipton lies in the unproductive belt, and the altitude of the Trenton here is some 35 feet lower than at productive wells five miles east or ten miles west from the city. This anticlinal appears to extend south to Sheridan and Joliet in Hamilton county and perhaps connects with the main field in the southern part of the county. We have no records to prove the extension of this anticlinal farther north than Kempton in western Tipton county.

Exceptional wells.—At Oakland, in northeastern Marion county, gas is found in the Trenton at 210 feet below tide, or about 100 feet lower than in adjacent wells, and below the level at which water usually occupies the rock. The record of the boring was kept by the secretary of the gas company and appears to be thoroughly reliable. This forms one of those puzzling exceptions which arise under nearly every rule. Another exception, equally puzzling, occurs at Auburn, in DeKalb county. The altitude of the Trenton is about 150 feet lower than at Garrett, a village five miles west from Auburn. No gas was obtained at Garrett, but a well estimated to furnish 1,500,000 cu. ft. per day was obtained at Auburn. The following rule laid down by Prof. Orton and found applicable nearly everywhere else apparently fails here. "The gas and oil are gathered in the arches of the Trenton if such there are. In default of arches the high-lying terraces are made to serve the same purpose, but the one indispensable element and condition of all accumulation is relief."[1] Prof. Orton explains the occurrence of gas at Bryan, Ohio, at an elevation 180 feet lower than that at Auburn, Indiana, as due to a minor elevation of the Trenton. In the same manner he explains its occurrence at Oak Harbor and Tiffin.[2] The only elevation we have discovered at Auburn and Bryan is that of a monoclinal rising from east to west. It is possible that at Garrett where the altitude seems to favor gas accumulation the texture of the rock is such as to exclude the gas.

Difference in altitude of saltwater line in Indiana and Ohio.—There is a marked difference in the altitude of the salt

[1] Geology of Ohio; vol. VI, p. 309.
[2] Geology of Ohio; vol. VI, p. 310.

water line in the gas fields of Indiana and Ohio. Since the anticlinal in Ohio is lower than that in Indiana and the amount of gas present is nearly as great as beneath an equal area of the Indiana anticlinal, the salt water line must be correspondingly lower.

Oil.—Oil has been struck in several places along the north border of the gas field, in northeastern Grant and northern Blackford counties, and also in southern Adams county near Berne. A large tract along the line where oil is found has been leased by oil-companies with a view to determining the value of the field. When we bear in mind that the Findlay oil field comprises a belt scarcely five miles long and but two miles wide, including within this area some unproductive territory, and yet contains a large number of profitable oil wells, it suggests the possibility that thorough exploration may bring to light one or more such fields in Indiana.

Oil has been struck at Royal Center, in Cass county. Attention has already been called to the higher altitude of the Trenton at this point. It is therefore an illustration of accumulation of hydrocarbons beneath anticlinals. We know of no borings in the vicinity of Royal Center which yield oil, but in this portion of the state deep borings are not so numerous as in the productive gas-field and its immediate borders. Altitude favors its occurrence along the line from Royal Center to Kentland but the rock texture may be unfavorable to oil or gas accumulation. We know, however, of nothing that indicates a change in the texture of the rock from the porous condition it displays in the gas field; on the contrary the outcrops of the upper portion of the Trenton in Illinois appear to be quite similar in structure to the Indiana gas rock.

Rock pressure.—Different theories have been advanced to account for the rock-pressure which the gas manifests. The one best substantiated ascribes it to the force exerted by the column of water which fills the Trenton from its outcrops in adjacent states down the inclined and porous portions of this limestone to the gas field. Here its pressure has driven the oil and gas into the anticlinals and terraces. This makes the gas expulsion a result of the same pressure that causes the water just outside the gas belt to rise from the Trenton in the form of artesian wells, and it is probable that as the gas becomes exhausted, water will follow it up from below and even-

tually take its place. The more rapid the escape of the gas the sooner will the supply be exhausted. The fortunate possessors of these wells will do wisely to heed the warning of those who have studied the history of gas wells in other localities and guard against the wanton waste of their treasure, for there are no grounds to support the belief that the supply is inexhaustible. Indeed, it is probably a question of but a few years till Indiana natural gas will be a thing of the past.

ON LINGULASMA, A NEW GENUS, AND EIGHT NEW SPECIES OF LINGULA AND TREMATIS.

[Continued from the last Number.]

BY E. O. ULRICH.

TREMATIS FRAGILIS, n. sp.

Fig. 6, 6 a, 6 b.

Shell large, nearly circular, the width a little greater than the length; substance exceedingly thin. Dorsal valve moderately convex, with the greatest convexity in the posterior half. Umbo small but rather prominent and the beak obtusely pointed and not projecting beyond the margin (sub-terminal). Cardinal slopes distinctly concave. Surface nearly smooth, with faint undulations marking stages of growth and very obscure concentric lines. Very minute punctures arranged in concentric and radial series, occur on and appear restricted to the concave slopes on each side of the umbo. Lower or ventral valve with a very small triangular foramen situated at the posterior end of a short but deeply impressed area. From the anterior end of this area, the surface rises slowly to a point about one-fourth of the length of the shell from the posterior margin, when it begins to descend and is slightly concave, in the region between the center of the valve and its lateral and front margins. The surface is marked as in the upper valve and here the fine punctures occur also for a short distance in front of the impressed foramen area. A specimen of average size is 24 mm. long, 25 mm. wide, and 4.5 mm. deep.

This species has about the same form as *T. ottawaensis* and *T. crassipuncta*, but the different surface marking will distinguish it readily from both. *T. punctostriata* Hall, has coarser puncta, these being also present over the whole surface of the dorsal valve. The foramen notch of the ventral valve, is also much larger, and the cardinal slopes of the dorsal

valve a little convex instead of concave. The species is distinguishable from all others known to me by the extreme thinness of its shell.

Formation and locality: Lowest beds of the Cincinnati group, a few miles south of Covington, Ky. Collections of Mr. C. Schuchert and the author.

TREMATIS CRASSIPUNCTA, n. sp.

Fig. 7-7 a.

Shell nearly circular, 15.5 mm. wide and 16 mm. long. Upper or dorsal valve moderately and uniformly convex, most elevated in the posterior half; beak very small, pointed, not elevated, and scarcely projecting beyond the margin. Surface with straight or zigzag radiating lines increasing by interpolation or bifurcation; the interspaces between them grow wider toward the front and lateral margins where from twelve to sixteen occur in 5 mm. The concave interspaces between them are not equal, some being considerably wider than the average with only three in 2 mm. The radiating lines are connected by cross ridges of which from twelve to fourteen occur in 5 mm., measuring from the margin. These lines form a rather coarse reticulation with meshes of quadrate, pentagonal or hexagonal form. In addition there are undulations of growth and very fine and crowded concentric lines. The latter, however, do not appear to have crossed the radiating striæ, having been noticed at the bottom of the depressed spaces.

Lower valve unknown.

At first I was disposed to regard this species as being identical with the *T. ottawaensis* of Billings. Since seeing the types of that beautiful species and collecting fine examples of it not only at the original locality, but also from the middle Trenton beds of Kentucky, I have come to the conclusion that the Ohio shell belongs to a distinct class. *T. ottawaensis* is a larger shell, slighter, wider and its surface reticulation finer. The average number of meshes in 5 mm. is nearly constantly twenty-five or twenty-six against twelve to sixteen in *T. crassipuncta*. The umbones of the upper valve of the latter is also less prominent and its beak more pointed and smaller.

Formation and locality: From shales of the middle beds of the Cincinnati group near the tops of the hills at Cincin-

nati, Ohio. The specimen figured belongs to the collection of Mr. Charles Schuchert. The figure represents the reticulation finer than is on the specimen.

TREMATIS UMBONATA, n sp.

Figs. 8-8 c.

Dorsal valve ovate acuminate, rather strongly convex, especially in the umbonal region, with the beak incurved and more or less acutely rounded. The length and breadth as well as the acuteness of the beak varies in different individuals. The extremes so far noticed are represented in the two specimens figured. Surface with fine and rather obscure concentric lines, and radiating series of minute punctures along the margins and on the umbonal slopes. The punctures are closely arranged and, as usual, increase slightly in size outward. They do not occur on all portions of the surface, being absent over a considerable part of the central region. Ventral valve concave, marked with fine concentric striæ and a number of crowded rows of very minute punctures on each side of the foramen notch. Foramen notch small and narrow, situated at the bottom of an abruptly impressed U-shaped area.

Two specimens have the following dimensions: (1), length, 16.8 mm.; width, 12.1 mm; convexity, 4.0 mm. (2), length 12.5 mm; width, 9.7 mm.; convexity, 3.8 mm.

The strongly elevated umbonal region of the dorsal valve, the concave ventral, and the elongate form, suffice to distinguish this species from *T. punctostriata* Hall. In all these respects *T. umbonata* simulates *T. huronensis* Billings, from the Black River limestone of Canada, but the surface ornamentation of that species as figured by Billings (Paælozoic Fossils vol. I, p. 52.) is quite different.

Formation and locality: Middle beds of the Cincinnati group on the hills west of Covington, Ky., and at the hill quarries of Cincinnati, Ohio. It is not by any means a common fossil. The types are from the collection of Mr. C. Schuchert.

TREMATIS OBLATA, n. sp.

Fig. 9, 9 a, and 9 b.

Trematis punctostriata Hall and Whitfield, Pal. Ohio, vol. II, pl. I, fig. 8; 1875.

Compare *Trematis punctostriata* Hall, 23rd Regent's Rept., p. 243, pl. 13, figs. 17 and 18; 1873.

Shell broadly oval to sub-pentagonal, wider than long, with the beak of the dorsal valve, and generally the anterior and posterior angles, slightly produced. Dorsal valve, when found in a shale matrix, only moderately convex, but specimens occurring in limestone have suffered less through compression, and are strongly convex, particularly in the region a little posterior to the middle. Umbo tumid with the cardinal slopes abrupt and occasionally slightly concave. Front margin nearly straight or gently convex, rounding more or less abruptly into the lateral borders. Beak acutely rounded, incurved to the plain of the posterior margin. Surface with obscure concentric lines and radiating series of punctures. The latter are usually absent, over the concentric region of the valve, are larger than in *T. umbonata*, increase in size outward, and near the front margins of large specimens form a network similar to that of *T. ottawaensis* and *crassipuncta*, only the meshes are not as large and the radial lines wider than in those species.

Ventral valve, so far as observed perfectly flat, save at the small impressed area at the bottom and posterior end of which is situated the small foramen notch. Surface with rather obscure concentric lines and radial series of punctures near the outer borders.

This species has generally been considered identical with *T. punctostriata*, described by Hall from hydraulic limestone of Trenton age (probably equivalent to the "Modiolopsis bed" of central Kentucky, at Clifton Terrace. Against this view I have only this to say, that if Hall's original figures are correct, and no one so far as is known to me claims that they are not, then the Cincinnati specimens clearly belong to a distinct species. It must be confessed, however, that the surface ornamentation seems to be very similar in the two forms and that they are in all probability closely related. Still, there are enough points in which they disagree to make a separation desirable and practicable. There is always a slight difference in the outline, and the umbonal region and the beak of the dorsal valve are more pronounced. Figs. 9 and 9 b of this paper illustrate extremes of variation in outline, while Hall and Whitfield's fig. 8, pl. I, vol. II, *Ohio Paleontology*, represents an average specimen. In comparing the ventral valve a more decided difference is noticed, the foramen notch in the

Tennessee form being much larger and longer than in the Cincinnati specimens. Under these circumstances I have felt myself justified in giving them a new name. *T. montrealensis* Billings, from the Trenton limestone of Canada, is apparently another nearly related form. Billings, however, does not mention radial series of punctures, so they are probably distinct.

Formation and locality: Not uncommon in the shales of the lower and middle beds of the Cincinnati group at Cincinnati and other localities in that vicinity.

THE AGE OF THE TIPTON RUN COAL OF BLAIR COUNTY PENNSYLVANIA.

By I. C. White.

The Tipton Run coal field lies along the eastern base of the Alleghany mountain, 12 to 15 miles north-east from Altoona, Pa. A country bank for local fuel supply, has been opened and operated there, near the head of Tipton run, and 4 miles distant from Tipton Station on the Pennsylvania R. R. for many years, but a branch line has recently been constructed to this field, and the coal is now mined and shipped to market on a commercial scale.

The elevation of the surface where the coal sets in is about 1400 feet above tide, or 800 feet below the summit of the Alleghanies, 1 to 2 miles away. As is well known to geologists this mountain range is here crowned by the Barrens, and lower Coal Measures, while lower down and forming the eastern escarpment, come successively the Pottsville conglomerate, Mauch Chunk red shale, Pocono sandstone, with the Catskill beds forming the base, and all arching into the air over the great Canoe valley and Morrison's Cove anticlinals. Lying thus topographically several hundred feet below the base of the lowest Coal Measures, and coming at the horizon of the Pocono, or No. X escarpment, this coal was long ago referred to the age of these Lower Carboniferous sandstones by the geologists of the First Geological Survey of Pennsylvania, and so far as the writer is aware this opinion has been confirmed by all professional geologists who have subsequently examined the field in question, the last being Mr. Chas. A. Ashburner, who made a special examination of the region after it had been opened for railway shipments. This report, which was more elaborate than any others, was published in 1886, and

like its predecessors, considers the Pocono age of the coal as indisputable.

Desirous of examining personally the locality where a bed of coal in the Pocono series was furnishing 30,000 tons of excellent fuel annually, the writer found occasion during the past year to visit the famous Tipton region. To his surprise he recognized the enclosing shales and sandstone as genuine Coal Measure sediments, while peeping out from a short interval beneath the coal bed was as good Pottsville conglomerate as that high above, along the eastern front of the Alleghanies, and within sight of the coal mine. Search for fossils was at once begun, and soon rewarded by the discovery of plant remains which confirmed the evidence from the character of the sediments. Hence there could be but one conclusion, a fault, or disturbance of some kind had dropped these beds down so as to bring Coal Measure rocks abutting against the Pocono, or Lower Carboniferous series. The succession of the rocks in the immediate vicinity of one of the coal openings is approximately as follows:

1.	Sandstone (probably the Freeport)		25′
2.	Concealed		50′
3.	Shales, plant-bearing		5′
4.	Coal	2′ 9″	3′ 9″
	Fire-clay, dark	2″	
	Coal	10″	
5.	Concealed		30′-50′
6.	Pottsville conglomerate visible		10′

The coal bed is probably identical with the Lower Kittanning, since the character of the fuel it furnishes, as well as the structure of the bed is much like the latter as seen on the top of the Alleghanies, a few miles distant. The two openings where the coal is now mined for shipment are on the same bed, No. 4 of the section, since the structure found in each is identical and the coal is of practically the same quality. The following fossil plants were found in the shale No. 3, which overlies the coal, the identifications in cases where the writer was in doubt having been made by Prof. Lesquereux.

Cordaites gracilis Lx.
Stigmaria ficoides Bt.
Lepidophyllum lanceolatum Bt.
Neuropteris tenuifolia Bt.
Neuropteris loschii Bt.
Alethopteris ambigua Lx.
Calamites, allied to suckowii Bt.
Pecopteris, sp.? fragment.
Alethopteris, allied to pennsylvanica Lx.

The plants are not abundant, and a much larger collection could doubtless be made by the expenditure of two or three weeks' time, but the list when considered with reference to the

character of the coal and the lithology of the enclosing rocks, is sufficient to demonstrate the Coal Measure age of the same. This list of plants was submitted to Prof. Wm. M. Fontaine, the eminent palæo-botanist, who is so well acquainted with the Pocono or Lower Carboniferous flora of Virginia and W. Virginia, and his opinion is the same as my own, viz., that the plants could come only in the Coal Measures. It is true that *Neuropteris tenuifolia* and *Sigillaria mamillaris* have been reported from the Pocono, since they are long-lived forms which pass from the base of the Carboniferous system almost to its top, and on this account Prof. Lesley would call the whole list Pocono plants, but we must recollect that neither *Pecopteris* nor *Alethopteris* have yet been found in the Pocono rocks of the Appalachian region. Then too, it is not alone the *presence* of typical Coal Measure forms which gives this list geological significance, but the *absence* of the types which everywhere else characterize the Pocono flora, as the archæopterids triphyllopterids, and small Lepidodendra; see "Permian Flora," Fontaine and White, pages 6, 7 and 8. The evidence from the character of the interstratified rocks is alone conclusive of the Coal Measure age. Any geologist thoroughly acquainted with the physical land lithological character of the sandstones and conglomerates of the Coal Measures, and also with those of the Pocono need not be told they differ from each other so greatly that it is not a difficult task to distinguish the one from the other. This difference consists in many things, the shape of the pebbles in the conglomerates (as shown by Mr. Carll), the character of the sandstones as to hardness, color, purity, &c., facts which are very real to the geologist who has noted them and learned them, but not readily embodied in description. The evidence of this nature is so strongly in favor of the Coal Measure age of the Tipton beds, that it would have been conclusive to me had no plants been found.

The coal furnished by this bed is quite as pure as the average of the Clearfield region which it adjoins, and this fact of itself should have some weight, in view of the well known reputation of the Pocono coals of Virginia, W. Virginia, &c., they all being very high in both ash and sulphur.

After this paper was about completed the writer learned from Prof. Lesley that Mr. J. W. Scott, a former mining engi-

neer, but now editor of the Altoona Daily Times, had several years ago claimed the existence of a "fault" in the Tipton Run region, and the consequent identity of the coal found there with the lower coals of Clearfield and Cambria Cos. This opinion was elaborated ten years ago in the Tyrone Herald (with which Mr. Scott was then connected), and consequently to him belongs the credit of having first determined the true age of the Tipton coal, though, as already stated, the writer was not aware of Mr. Scott's work until after he had arrived at the same conclusion.

Mr. Scott claims to have traced the line of "fault" through from the Clearfield region to Tipton run, but the writer has no personal knowledge as to the particular form of disturbance that has dropped the lower Coal Measures down out of their regular place in the Tipton region. Whether it be a genuine "fault," or a deep local syncline, separated from the coal area west and north of it by erosion, or any other form of displacement, has not been determined for lack of time and a good map of the region.

METEORITES AND WHAT THEY TEACH US.

I.

By H. Hensoldt, Ph. D.
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The nebular hypothesis of the great Laplace, which very ingeniously accounts for the origin of what we call heavenly bodies by assuming that the materials now composing them, say the elements, were at one time distributed in a gaseous state through space, throughout vast and theoretically, infinite space, that our present worlds are the outcome of an elaborate condensation process which these originally rarefied materials underwent, the accounting for planets or satellites travelling around a central body by assuming that they owe their origin to a ring or a succession of rings thrown off by this central body, from its equatorial region, in consequence of the centrifugal force getting the better of the centripetal—this wonderful nebular hypothesis has been recently and is even now in danger of being superseded by another, not quite so "sublime" if I may use this word, though grand enough in some of its aspects, but one which, if it appeals less to our imagination is more capable of verification by direct observation and which apparently carries a far greater degree of probability.

This new hypothesis may be termed the dust-hypothesis. It assumes that the universe, or a great part of it, is full of minute, dust-like particles of heterogeneous character, floating about in the ether or travelling in definite courses, that if one of these particles happens to come in contact with another, or very near it there is mutual attraction and adhesion, that the joined particles will travel onward with their attracting force thus increased, drawing other particles to them, one here, and one there, and form the nucleus of a body which keeps growing as it travels into new regions of space, exhausting them of the materials within its reach. The more it grows, the more its sphere of attraction increases the more rapid the accumulation, which is unlimited, till we have a mass a foot in diameter, a planet like our earth, a vast body like the sun or some still grander one, like that distant giant which compels our sun to travel in its unknown course.

This new hypothesis, which deserves our closest attention,as it throws a new light on the origin and character of our own planet, and which is calculated to revolutionize our present conceptions of geological research, is the outcome of the study of meteorites,—those remarkable bodies of extra-terrestrial origin, which are now so eagerly collected and so highly valued although less than a hundred years ago they were barely noticed or at best regarded merely as curiosities by the learned or as objects of evil portent by the superstitious.

It may seem incredible to those who hear it for the first time that a globe like the earth, with its diameter of eight thousand miles, should be a mere accumulation of particles, gathered around a nucleus of cosmic dust, as it travelled on its way through cold and pathless oceans of space. But we have the fact of our earth constantly attracting to its surface substances from the inter-planetary regions, from the most impalpable dust to meteoric masses weighing tons, a process which has been going on year by year through the geological ages of a duration probably incomprehensible by us. The earth is increasing in weight thousands of tons annually through the fall of meteorites alone, but this is as nothing compared with the aggregate weight of the dust-like particles attracted to its surface during a like period. Prof. Nordenskjöld, on his various expeditions to Greenland, as well as on his famous Vega expedition, frequently observed the snow or

ice covered with metalliferous dust and other particles which were doubtless of cosmic origin, as they were found in regions far from the habitations of man and were unlike anything that could have been transported there by atmospheric or other agencies from a terrestrial source; and no matter *where* he examined snow, whether in Greenland, Spitzbergen, or the frozen coast of Siberia or in his own native Sweden, he never collected less than a millegramme in weight of meteoric particles from a square yard of surface. In one region, for instance, on his Vega expedition he found the snow covered for miles in extent with minute and very perfect crystals of yellowish color, like crystalized sand-grains. They were about 1 mm. in diameter and seemed to belong to the rhombic system, as they had one perfect cleavage and formed striated prisms, terminated at either end by a truncated pyramid.

Now one millegramme to every square yard of the earth's surface, which is probably far below the *annual* fall of meteoric dust-particles, amounts for the whole globe to no less than five hundred million kilograms—about half a million tons—too important a factor to be neglected when the fundamental facts of the geological history of our planet are enumerated. That small quantities of cosmic dust, containing iron, nickel, cobalt, carbonaceous substances and phosphorus, constantly fall, with other atmospheric precipitates, on the earth's surface is a well established fact and there is even ground for believing that this deposit may play an important part in the economy of nature in supplying phosphorus to soils already exhausted by the growth of crops. Farmers have long been taught by experience that an exhausted field, if left untilled for a number of years, will regain its fertility in proportion to the length of time during which it remained fallow.

The earth, travelling in its orbit around the sun, and onwards with the entire solar system around some unknown and still greater center of attraction, is constantly traversing new regions of space, which it depletes of meteoric dust and meteorites, thus steadily—no matter how slowly—increasing in diameter. Now let this growth continue till the earth has just twice the attractive power which it now possesses; we should then have twice the number of meteorites and double the quantity of dust falling annually upon it than now. Fortunately for our heads the earth has not as yet attained very formidable dimensions,

but wè may look upon it as an established fact that it constantly gains in weight and that in proportion to such gain its attractive power steadily increases. The attracting force of the sun is so enormous that a perpetual hail of meteorites and a torrent of dust-particles must rush upon it from all directions, and some of the foremost observers are now of opinion that these falling bodies are the sole cause of the sun's heat. In the light of this theory our earth is a young and growing, not an old and dying planet, a planet with a future, which ought to be cheerful news to all of us although we shall not live to reap the benefit of it, and the sun, far from being on its last legs as an expiring luminary is steadily gaining in heat and lighting capacity.

Now in how far do the facts revealed as yet by the study of meteorites support this hypothesis and what do meteorites teach us in reference to the character of our own planet? That an accumulation of cosmical particles, no matter how small, is in itself sufficient to account for the origin of planetary masses or fixed stars, no matter how large, nobody can deny after a moment's reflection; it is merely a matter of time for any given body to attain any given size, and if the accumulation is at first extremely slow it must not be forgotten that it increases enormously with the growth of the mass.

But since the internal structure of meteorites, and especially that of the so-called stone-meteorites, has been more carefully studied, *additional* evidence has been furnished which almost amounts to proof that at least many of the meteorites now in our museums and private collections have originated from the accumulation of small particles in the manner above described. Gustav Rose of Berlin, one of the most careful observers, and whose classification of meteorites is now adopted even by the great Tschermak, the meteorite-investigator par excellence, Gustav Rose was the first to draw attention to the fact that the majority of the stone-meteorites as yet discovered, are composed of little spheres or "chondri," globular masses, varying in diameter from the merest dust to that of a walnut. He proposed the name of *chondrites* for such masses, but they form a class so great in proportion to the rest of the recorded stone-meteorites that Tschermak found it necessary to subdivide them into more than half a dozen varieties or species. This chondritic structure is different from anything we find in

terrestrial rocks, except, perhaps, in the oölitic limestones, but here due to totally different causes.

These meteorites are composed of little spheres or globes, either perfectly round or slightly oval, sometimes flattened or pressed, as it were, out of shape, and either cemented together by an interstitial paste or matrix, or adhering only loosely with little or no interstitial matter to bind them. These chondri consist of minerals which are also of common occurrence in terrestrial rocks, although never in this peculiar form. They are either composed of olivine, bronzite, augite, triclinic feldspar or metallic iron, or of two, seldom three, of these combined, never of anything else, except occasionally of glassy matter. The most significant fact is that nearly every chondrum is surrounded by a *distinct crust* as if it had once been an independent cosmical body—a miniature meteorite—and perhaps equally remarkable is the resemblance, not merely in structure, but in composition, between these chondritic meteorites; and we must bear in mind that of every ten stone-meteorites eight at least are chondritic. This resemblance is perfectly astonishing and all the more so as we have nothing like it among terrestrial rocks. Every experienced petrographer knows that terrestrial rocks of the same character and composition will present, under the microscope the most striking structural differences if they are merely gathered from different localities (often less than half a mile distant from each other). No two granites, basalts, dolerites, serpentines are alike. There are differences even in the same granite from the same locality and if we prepare twenty sections from one piece not larger than a walnut, the probabilities are that each will show something that can not be observed in any of the others.

But the chondritic meteorites, no matter when or where they fell, whether in Japan or the desert of Sahara, in Great Britain or Bolivia, practically agree in structure and composition and the resemblance is often so great that even a Daubrée or Tschermak could not, in many instances, tell the section of one from that of another except by its label. Thus, for instance, the meteorites of Dhurmsala and Fayette county are absolutely identical in mineralogical composition as well as structure, the similarity extending even to the smallest microscopical details. The former fell 29 years ago in the Punjaub,

India, while the latter—the largest and perhaps the finest stone-meteorite as yet discovered on the continent of America—was found by the writer near Lagrange, Texas, in January, 1888. Now these localities are more than 6,000 miles distant from each other and there is also a great difference in the dates of fall (the Fayette county meteorite, from the appearance of its crust, must have fallen more than fifty years ago) yet the microscope reveals absolutely no difference in the sections Always the same chondri or their fragments, always the same five minerals: olivine, bronzite, augite, plagioclase and iron as the principal constituents. This would tend to show that there exists a surprising uniformity among the cosmical particles from which meteorites originate.

Fortunately the labors of Tschermak and Daubrée have made it possible for us to distinguish without much trouble, an olivine chondrum from one of augite, bronzite or triclinic feldspar, but as we can not here go into elaborate details we merely point out in a general way that chondri which are traversed by parallel bars, or a sort of grating, may be put down as olivine, those with a granular structure as augite, those exhibiting a fine parallel striation between crossed-Nicols as triclinic feldspar and those which show a peculiar fibrous, radiating or fan-like structure, as bronzite. The feldspar is almost invariably anorthite, the most basic of all feldspars—a significant fact as we shall see later on, but we occasionally meet with a peculiar *singly-refractive* variety of plagioclase, which has been called maskelynite, but which in the opinion of the writer is nothing but anorthite rendered singly-refractive by partial fusion. The astonishing similarity between chondritic meteorites enables us to limit our description to a few prominent types. The meteorite of Renazzo, which fell in Italy in 1824, consists of chondri, cemented together by a dark paste of carbonaceous matter, in which an immense number of particles of pure iron are distributed. These of course can not be distinguished under the microscope from the black matrix, as both are perfectly opaque. But an ordinary hand-lens reveals the remarkable fact that each chondrum is surrounded by a *crust of metallic iron.* Sometimes this crust is very thick, so that it often seems as if a chondrum of iron had a nucleus of olivine. The Tieschitz meteorite which fell in Moravia in 1878, is composed, in part,

of very perfect chondri, but the section also reveals a number of angular fragments. Bronzite chondri, recognizable by their peculiar fan-like or fibrous structures, are beautifully developed. Many will remember that about ten years ago Dr. O. Hahn, of Reutlingen, a lawyer by profession, rushed into print and insisted upon making himself ridiculous by the publication of a bulky work with 32 photographic plates on organic remains in meteorites, which he pretended to have discovered. This worthy man, who had little petrographical knowledge, was entirely misled by the fibrous structure of these bronzite chondri, which is often very curious, reminding one of fossil corals, and he took great pains in describing no less than twenty-eight species of corals alone, besides many sponges, crinoids and what not in the organic line, which he had discovered in meteoric sections, but which nobody else could see in them. He was guided by accidental resemblances; the things he observed were such as one might see in the clouds and anyone gifted with a little imagination will, if he looks long enough, discover corals, foraminifera, fossil fishes and even dromedaries in almost every section prepared from a chondritic meteorite.

The Monroe meteorite, which fell in Cabarras county, North Carolina, in 1849, does not at first sight appear very chondritic, but if we carefully examine a thin section we find it to be almost entirely composed of chondri closely packed or welded together and somewhat pressed out of shape. Still more difficult is it to recognize the chondri in the meteorite of Aumale, Algeria, yet it is a chondrite and we can still distinguish the parallel bars of the olivine, the coarse granulation of the augite, the striation of the feldspar and the radiating fibres of the bronzite.

Chondritic structure, as already shown is peculiar to meteorites. We have nothing analogous in terrestrial rocks except in the oölitic limestones, but here due to entirely different causes. In the Portland oölite from England for instance, we have spherical deposits of carbonate of lime which have formed in concentric crusts around nuclei. These nuclei consist of sand-grains, and sand-grains also form the interstitial substance between the little globes. Such a section presents a strikingly beautiful appearance in polarized light, as the lively chromatic display of the quartz nuclei contrasts

with the layers of carbonate of lime, which are indifferent to polarization. We also find occasionally in terrestrial rocks, and especially in eruptive ones, a tendency on the part of certain crystals to gather around some nucleus and form spherical aggregations, viz: during the process of solidification or cooling of a molten mass crystals will sometimes arrange themselves very symmetrically around some nucleus as in certain augite lavas of Tahiti. Again in sections of Cornish granites, especially of the famous luxulyanite, which is found in bowlders in the vale of Luxulyan, Cornwall, we have needle-shaped crystals of tourmaline radiating star-like from a common center—a marvelous object for the polariscope; but all these phenomena are essentially different from those presented by the chondri of meteorites.

But if from such data as these, viz., from the fact that the great majority of the known stone meteorites are chondritic, meteorite-investigators who are petrographers, and astronomers who are *not* petrographers, jump to the conclusion that *all* meteorites have resulted from the accumulation of cosmic particles, they are in our humble opinion, greatly mistaken. That the true chondrites have originated in this manner is extremely probable and if our individual opinion is worth anything the writer may add that he is perfectly convinced of it. But then we have quite a number of stone-meteorites which are not only *not* chondritic, but which are so constituted as to preclude the possibility of their ever having *been* chondritic, and which for a number of other reasons cannot have resulted from an accumulation of cosmical particles. Some of these meteorites have a *brecciated* structure, almost identical with that of some of our volcanic ash-rocks and tuffs. They consist of little angular fragments, mixed with larger ones, broken crystals of various silicates and other detritus, exactly as we find it in volcanic ash-rocks. Of this class the meteorite of Petersburg which fell in Lincoln county, Tenn., in 1855 is an example. In a section prepared from this meteorite we see nothing but sharp fragments and grains of pyroxene, plagioclase and a variety of other minerals difficult to determine; a number of rusty spots are due to limonite, which has resulted from the decomposition of some of the iron particles. Very similar, only a little coarser in structure, is the Frankfort meteorite, which fell in Franklin county, Alabama, in 1868. A glance at the

sections of these meteorites suffices to convince us that they represent a totally different type, that they have nothing in common with the chondrites before described, and it so happens that they agree in almost every particular with certain of our ash-rocks and tuffs. In the writer's opinion they cannot have originated in any manner differing fundamentally from that, which led to the formation of our compressed terrestrial ash-rocks. In sections prepared from certain volcanic ash-beds in Central America, Arizona and California we have essentially the same structure and very nearly the same mineralogical composition, the same angular fragments, the same detritus, the same color even; and we might go on multiplying such examples of almost absolute coincidence.

Another meteorite which will not fit in the accumulation-hypothesis and which greatly bothers the dust-people, is the famous meteorite of Rittersgrün, one of the most remarkable and beautiful meteorites,which fell in Saxony in the year 1164. It is composed of metallic iron and crystals of a beautiful yellowish green color, which at first were believed to be olivine but which are now known to be bronzite. Then we have meteorites of a basaltic structure, like that of Juvinas, which fell in France in 1821. It is chiefly composed of rods of triclinic feldspar (anorthite) and augite. Such crystals could only have originated during the very slow cooling of a molten mass under extreme pressure. Now the structure of the famous Ovifak basalt is so similar to that of the Juvinas meteorite that it is almost impossible to distinguish, under the microscope, the sections of the former from that of the latter. The Ovifak rock is composed of the same minerals, in the same proportion and in precisely the same development, viz., rods of anorthite, granules of augite and native iron. Native iron! Where did that come from? What business has metallic iron in a terrestrial rock? Well, the basalt of Ovifak *is* the most remarkable terrestrial rock with which we are acquainted. Its discovery has been a great shock to the army of meteorite-collectors all over the world, a shock from which they have not even yet quite recovered, for now the presence of metallic iron can no longer be relied on as a test-feature of a meteorite.

Previous to Nordenskjöld's great discovery, non-artificial metallic iron had never been known to occur on this terres-

trial globe, whether as a constituent of rocks or in the shape of veins, lodes, crystals or loose masses. It was invariably found oxydized or combined with carbon, silica, sulphur and other substances from which it had to be first separated by more or less complicated processes. But metallic iron was met with in the meteorites which have from time to time fallen upon the surface of our planet. These mysterious visitors from other spheres not only often *contain* iron but they are in the majority of cases almost entirely composed of it and it is more than probable that the first iron with which man became acquainted and which he used for tools and implements, was the iron of meteorites.

When Cortez had completed the conquest of Mexico, the Spaniards, among a great many other peculiar and extraordinary observations which they made in that remarkable country were particularly struck and puzzled by one fact. They noticed that the Aztecs possessed certain implements, such as knives, daggers, etc., made of iron, but it seemed that only the most distinguished of the natives possessed such, that iron was a great rarity and was prized higher than gold. At first the Spaniards believed that the Aztecs extracted the metal in some crude fashion from its ore, which abounded in many parts of the country, but they soon ascertained that this was not the case. They found that not a single smelting furnace existed in the empire and their surprise was not small when they learned that the Aztecs were totally unacquainted with any method of extracting the iron from the ore, which indeed they had never suspected of any kinship with the highly valued metal. The question whence the Aztecs had procured the little iron they possessed became a perplexing problem to the Spaniards, a problem which they were never able to solve. The natives do not seem to have enlightened them much on the subject, for when asked, they mysteriously pointed to the sky and indicated that they obtained their iron from the regions above. Such assertions no doubt the Spaniards received with an incredulous smile and they concluded that the Aztecs procured it by way of traffic from some other, perhaps more civilized nation, which they suspected to exist and kept looking for, North and South for more than a hundred years. It was left to modern science to unravel the mystery. The Aztecs were quite correct, the iron of which they had made their imple-

ments was not fashioned from materials of this terrestrial globe but had come to them from the unknown regions of space. Their iron was, in fact of meteoric origin, like that of the Mayas of Yucatan and the Incas of Peru of which many weapons are still preserved in collections.

(Continued.)

THE GENERAL INTERIOR CONDITION OF THE EARTH.[1]

BY JOSEPH LE CONTE.

It is well known that the interior temperature of the earth increases at the average rate of 1° for every 50-60 feet of depth. For convenience we will take it at 1° for every 52.8 feet, or 100° per mile. At this rate at the depth of 25 miles we should reach a temperature at which all ordinary rocks would melt. The older geologists therefore assumed that the earth is an incandescent liquid globe beneath a comparatively thin solid crust.

But physicists now tell us that this is impossible. Thomson and Darwin[2] have conclusively shown that in all its cosmic relations, and especially under the tide-generating influences of the sun and moon, the earth behaves not like a substantially liquid, but like a substantially solid and very rigid body; that in fact it is, as a whole, more rigid than a globe of glass and even as rigid as a solid globe of steel of the same size.

An outline of the physical argument may be briefly put as follows: Suppose, 1st, the earth to be a liquid globe of mercury revolving as now under the moon. Evidently a tide affecting the whole mass (earth tide), would follow the moon. Suppose, 2nd, such an earth covered two miles deep with a universal ocean. In this case there would be a tide affecting the whole compound mass; but the water-tide, upon the mercury-tide, being but $\frac{1}{2000}$ of the whole would be imperceptible. Suppose, 3rd, a liquid globe covered by a solid shell 25 miles

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[1]This paper was given as a lecture before the California Academy of Science, May 7th, 1888. Having delayed publication, and an admirable paper on the same subject and reaching similar conclusions by Prof. Claypole having in the meantime appeared in the June and July numbers of this magazine, I gave up the idea of publishing at all. But I find the mode of presentation so different that on second thought I still believe the paper may be useful at least to teachers of geology.

[2]Nature, vol. 27. p. 22, 1882; vol. 14, p. 426, 1876. Thomson and Tait, Natural Philosophy.

thick and the whole covered with water as before. Such a globe would behave exactly or almost exactly like a perfectly liquid globe. There would still be an earth-tide but no perceptible water-tide, *i. e.* no perceptible *deepening* of the water under the moon. The water-tide would be completely or nearly completely destroyed by the earth-tide. Suppose 4th, and finally, a perfectly solid and rigid earth covered with ocean. The tide, now, would be wholly a water-tide upon the unyielding earth, and would therefore be very perceptible. This is substantially the condition of things now on our globe. Now, physicists assert that if the earth were a liquid covered with a solid shell 50 miles or 100 miles, or even 500 miles thick, it would yield sufficiently to practically nullify the water-tide. I think therefore we must admit that the physicists are right and that the earth as a whole is rigid and therefore that it is a substantially solid globe.

But, on the other hand, there are many geological phenomena which seem to demand an unlimited supply of liquid matter beneath a comparatively thin crust. Passing over volcanoes which may be connected only with *local* reservoirs of liquid matter, the most important of these are the following: (1.) *Great lavafloods*—such as that of the northwest, covering at least 150,000 square miles 2000-3000 feet deep, and that of the Deccan plateau covering 200,000 square miles 6,000 feet deep. (2.) *The formation of mountain ranges* by lateral pressure. The *concentration* of the effects of lateral pressure along certain lines seems to require some slippage of the crust, on the deeper parts; but this would be impossible if the world were solid throughout. (3.) The oscillating movements of the crust over wide areas and especially subsidence under the weight of accumulating sediments and rising under the removal of weight by erosion.

The house of Science seems then to be divided against itself. How shall it stand? Under the pressure of this dilemma geologists have been more and more driven to accept a compromise view; or rather a view which combines and reconciles these two opposite and mutually excluding extremes, and therefore is more rational than either. According to this new view the general constitution of the earth is that of a solid nucleus composing its great mass, a solid crust of inconsiderable thickness, and a liquid or semi-liquid layer between. This

last we will call the "*sub-crust liquid layer.*" This view would give substantial solidity and rigidity to the earth taken as a whole and would therefore satisfy the physicists, and at the same time would account for all the phenomena spoken of above and therefore satisfy the geologists. The object of this note is to show in a simple way, which I have long used in my class lectures, that such a constitution is in full accord with known physical laws.

If in fig. 1, *s s* be the surface of the earth and *a b* a portion of the radius; and if taking these as coördinate axes, we measure depths on *a b* and corresponding temperatures on *s s*; then a *uniform* rate of increase would be correctly represented by the straight line *c d* and at the depth of twenty-five miles, x, the heat-ordinate of 2,500° would be reached. And if this temperature be taken as the fusing point of rocks it would seem, and has been concluded, that all below is liquid.

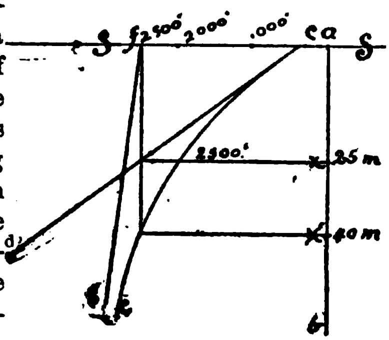

Fig. 1. *ss*=Surface of earth, *ab*=part of radius, *c d*=line of uniform increase of temperature *c e*=line of actual increase, *f g* =line of fusion.

But there are many general reasons for thinking that the interior temperature *does not* increase uniformly for all depths, but at a continually decreasing rate[1] and therefore that the line correctly representing the increase, is not a straight, but a curved line like *c e*. The assumed fusing temperature of 2,500° would therefore not be reached at 25 miles but much lower down, say at x′ perhaps 40 miles. Here then at last we would have fusion if the fusing point at that depth were 2,500°. But not so; for the fusing point of all bodies, except a few like ice which contract in the act of fusion, is raised by pressure and in proportion to pressure. In the figure the line *f g* represents this increase of fusing point with depth. Hopkins[2] has made many experiments on the more fusible solids—such as sulphur, wax, stearine, &c., to determine the rate of eleva-

[1]Geol. Mag. vol. 7, p. 99, 1880.
[2] British Assc. Report 1854.

tion of fusing point with pressure and found a mean rate of 1° for 30 atmospheres. It is possible that the rate of elevation for rocks may be less than this: but in any case there must be a notable elevation of fusing point by the enormous pressure of 30-40 miles of rock. Therefore we must go still deeper to find fused matter. In the meantime the pressure would still increase and the fusing point be still more elevated. Whether, in this chase of the increasing temperature after the flying fusing point, the former would overtake the latter at all; and if so, where, are questions we cannot answer positively. It would depend on the relation of the rate of increasing temperature with depth to the rate of elevation of fusing point with pressure, *i e*, the relation of the line *c e* to the line *f g* (fig. 1).

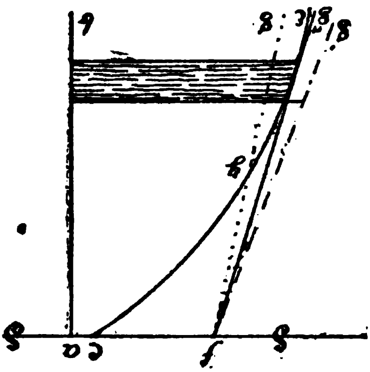

Fig. 2. *a c*=line of actual temperature, *f g f g'* x *f g''*=supposed lines of fusion. Shaded part=sub-crust liquid.

There are three possible cases in this regard. 1. The line of fusing point may take the direction *f g* (fig 2.) putting the line of actual temperature at *y* and ever after lying within. In this case the earth would be universally liquid below *y*. This would not satisfy the physicists. 2. It may take the direction *f g'* and lie wholly outside of the line of actual temperature. In this case the earth would be solid throughout. This would not satisfy the geologists. 3. The line of fusing point may take the direction *f g''* touching or cutting and again leaving the line of actual temperature. In this case at the depth of tangency there would be a layer of fused or semifused matter separating a solid nucleus from the solid crust. For reasons already given this seems to be the most probable case, for this would explain all the phenomena and satisfy both the physicist and the geologist.

Now there are some reasons for thinking that this sub-crust layer would not be so deep as would seem from the foregoing reasoning and figures. We have thus far supposed the line of fusing point a straight line. This would probably be the case if

the density of the earth and therefore the increase of pressure were uniform. But the earth undoubtedly increases in density with depth. Therefore the pressure and therefore also the elevation of fusing point increases *at an increasing rate.* Therefore the line of fusion is a line *concave outwards* (fig. 3, *f g*).

The probability of touching and even *cutting and again leaving* is thus greatby increased, and the possibility of cutting *higher up* and still escaping is also increased. Thus the probability of the existence of a subcrust layer would be increased, its position would be nearer the surface and its thickness would be less on this view than on the supposition of the line of fusion being a straight line.

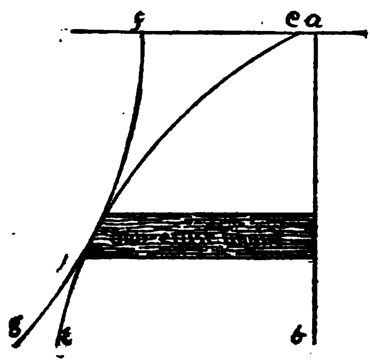

Fig. 3. c e=line of actual temperature, *f g*= line of fusion.

But there is still another principle not yet taken into account. We have thus far taken the fusing point at 2,500°. This is about the fusing point of rocks under dry heat. But in the presence of water and in proportion to its percentage fusion of rocks will take place at a much lower temperature. If the percentage of water be sufficient it may take place at 800°-1,000° F. To distinguish it from true dry igneous fusion this has been called aqueo-igneous or hydrothermal fusion. Now, water is found at all depths to which we have penetrated the earth. All lavas also contain water combined with the fused magma in greater or less quantity. If by this consideration we reduce the temperature of fusion we should thereby render the existence of a sub-crust liquid still more certain and bring its position still nearer the surface.

It seems almost certain therefore that the interior constitution of the earth *is* that of a substantially solid globe; but with a sub-crust liquid layer separating a solid nucleus from a solid shell; and that the layer is not very many miles below the surface nor is it of any great thickness.

The manner in which the sub-crust layer was formed was

probably in outline as follows: In the originally incandescent liquid condition of the earth, as long as the liquidity was perfect, convective currents would tend to keep the whole mass at nearly equal temperature throughout. The cooling mass therefore commenced to solidify at the centre, because the pressure was greatest there. The nucleus thus formed, continued to grow in size until it nearly reached the surface. But when the surface liquid by cooling had become viscous, so that convective currents were impeded a superficial solid crust would be formed by radiation. The sub-crust liquid thus formed was now encroached upon on one side by the solid crust and on the other by the solid nucleus until at present it is comparatively thin or perhaps abolished entirely in many places and the crust united with the nucleus. This is probably the condition of things now; for there are some geological facts, especially the existence of those greatest features of the earth surface, constituting continental masses and oceanic bottoms, which seem inconsistent with the existence of a *universal* sub-crust liquid obeying the laws of hydrostatic level.

The original liquid magma, undoubtedly increased in density to the center; and that, not only by increasing pressure but by difference of materials and especially by superficial oxidation. Therefore the solid crust may be regarded as *floating* on the sub-crust liquid even though (as is almost certain) rocks become denser by solidification. The instability of such a floating crust under the weighting by sedimentation and lightening by erosion is sufficiently obvious. But these effects may be increased in the manner suggested by Lloyd Morgan.[1] Sedimentation increases the weight and therefore produces subsidence of the floating crust; but increased weight means increased pressure, and increased pressure produces solidification of the upper parts of the sub-crust liquid, and solidification means increased density and therefore contraction, and this again produces further settling down of the crust. Contrarily, erosion by lightening the floating crust produces elevation, but lightening the pressure produces fusion of the lower portion of the crust, and fusion produces expansion, and this again in its turn increases the elevation. In some such way we may account for the pari passu subsidence under

[1] Geol. Mag., vol. 5, p. 291. 1888.

sedimentation and elevation under erosion, so common in every period of the earth's history.

It would be a mistake however to suppose, as many do, that all crust oscillations are the result of weighting and lightening by sedimentation and erosion. There are undoubtedly other causes, far more fundamental, determining these movements. Subsidence is often not the result but the *cause* of excessive sedimentation by continual renewal of the conditions of sedimentation; and elevation is often the *cause* of excessive erosion by renewal of the conditions of erosion.[2] That elevation is often produced by other causes besides lightening by erosion, is evident in cases of great lava-floods, where the crust is lifted by upswelling of the sub-crust liquid and broken by great fissures through which the sub-liquid is outpoured on the surface and the broken crust block readjusted by gravity in new positions. What is the cause of the intumescence of the sub-liquid in these cases, whether elastic force of steam incorporated in the magma by excess of water from above, or whether by hydrostatic pressure transferred from a subsiding area somewhere else, we do not know.

THE LATE SESSION OF THE INTERNATIONAL CONGRESS OF GEOLOGISTS AT LONDON.

BY PERSIFOR FRAZER.

Although several members of the late Congress took ample notes of the proceedings, no one has put his notes into the form of a permanent record in advance of the official volume, except Col. Joaquim Filippe da Encarnaçao Delgado of the Portuguese engineer corps, director of the Geological Survey of Portugal.

There have been several causes for this; one is that the discussions at the London Congress settled very little if any thing, and barely if at all raised themselves above the commonplace discussions in an ordinary meeting of a geological society. The Congress had no very important message for the world, and the world was not anxious to be informed of the usiness transacted by the Congress.

Another reason may have been that those who were prepared to give an account of the Congress were too busy to do so;

[2] Amer. Jour., vol. 32, p. 180; 1886.

but the principal reason is probably because from the representations of the English committee everybody believed that the official volume itself would appear in a few weeks or, at most, a few months after the adjournment of the Congress. One can only surmise what has caused the delay, but the fear is that in spite of the anticipations of the London committee the volume is (apparently) as far from being issued as it was four months ago.

The writer had the pleasure of presenting an account of the Berlin Congress in the columns of the *American Journal of Science*, Dec. 1885, and very shortly afterwards a volume with a few and unimportant changes which had received the revision and endorsement of all those who took part in the debates of the Congress. The official volume of this, the third session of the Congress corresponds closely with the smaller digest, which was the only connected statement of the proceedings of the Congress accessible during the interval of three years from 1885 until 1888.

He knows from personal experience the difficulties which beset the path of the unofficial reporter of proceedings like these and can the more heartily accord his praise to the large quarto pamphlet of the learned and distinguished chief of the geological service of Portugal.

There were some notable improvements over the methods employed in Berlin which were noticeable in the London Congress and especially in the daily reports of the proceedings of the Council and of the general session of the Congress itself; with the untiring aid of the Abbé Renard, Dr. Charles Barrois, and Dr. C. LeNeve Foster, the two sets of Journals were written out in full every day and printed at night, so that in the morning when the Council met at 9:30 A. M., each member found lying before him on yellow paper, a record of the Council's proceedings of the day before, by the aid of which he could closely follow and intelligently amend the account read by the Secretary. The same was true when the Congress met after the Council meeting. The proceedings of the day before printed on white paper were distributed among the members. This convenience was due to the fore-thought of Mr. Topley and the devotion of the three gentlemen named above who frequently spent the greater part of the night in the work. It is the more surprising that with this troublesome matter of routine busi-

ness and debate out of the way, and the memoirs destined to publication in manuscript in the hands of the Secretaries, the official volume has not been out a month or more ago.

The title of Col. Delgado's book is "Account of the fourth session of the International Geological Congress held in London in the month of September, 1888, by Joaquim Filippe da Encarnação Delgado, Colonel of Engineers, Director of the geological works. Lisbon, National Press, 1889." The following is a summary of this book made by one who is not familiar with Portuguese.

After relating that the sessions were held in the amphitheater of the University of London, and the arrangements were perfect to satisfy all the wants of such a Congress, he mentions that the first session was held the 17th of Sept. and the last on the 22d. The week following the sessions was devoted to geological excursions so arranged that those interested in any particular part of the geological column were provided with an opportunity of studying it. The meeting of the British Association for the advancement of Science preceded that of the Congress, having been held in Bath from the 5th to the 12th of September where likewise geological excursions were organized so that one could observe the upper paleozoic and the lower secondary rocks.

The number of foreigners present at the Congress exceeded by many those at its other sessions. At Paris the number of members enrolled was 304, of which 194 were Frenchmen, and 110 foreigners representing 20 different countries. The number of members enrolled at London was 835, of which 348 were foreigners representing 26 countries in Europe, Asia, America and Australia. Of the number 380 actually present at the London session there were 140 who represented foreign countries or distant colonies of Great Britian. The following table gives the statistics on this subject. (See Page 47.)

The advantage of personal contact of such a large number of geologists from all parts of the world is evident, and the preceding table is the best argument in favor of the importance of an international geological congress, though certain members for reasons not easy to understand predicted before the opening of the session that the London session would be the last.

The programme of the ordinary work of the Congress con-

sisted in the discussion of questions which hitherto had not been treated at all or which had been insufficiently discussed at Berlin. Among the principal subjects of discussion should be mentioned especially a discussion relative to the geological map of Europe; the classification of the Cambrian and Silurian, and the Tertiary measures. The organizing committee resolved that one special session should be devoted to the discussion of the crystalline schists, and also that various questions of nomenclature should be treated which as yet had not been resolved by previous Congresses, or which the international committee on nomenclature had presented through the medium of the secretary.

	Number Subscribing to the Congress.	Number actually present.
British Isles	487	240
Germany	67	28
United States	63	17
France	49	17
Italy	37	11
Belgium	34	14
Russia	20	13
Austro-Hungary	17	10
Switzerland	8	4
Sweden	7	5
Canada	7	3
Roumania	6	3
Spain	4	4
Norway	4	2
Holland	4	2
New Zealand	4	1
Portugal	3	2
Mexico	3	2
The Antilles	2	0
Australia	2	0
India	2	1
Bulgaria	1	1
Denmark	1	0
Luxemburg	1	0
Peru	1	0
Argentine Republic	1	0
Total	835	380

A large number of elaborate memoirs were presented by different geologists in order to facilitate the discussion and especially the discussion relative to the crystalline schists, the organizing committee having taken care to solicit from various

foreign specialists their collaboration and having printed the different works sent in one volume which was distributed among the members of the Congress.

The Congress began its session at 7:30 p. m. on Sept. 17, a great number of geologists being present. On the same day the committee on the map of Europe, the committee on nomenclature, and the Council had prepared divers reports, amongst others the nomination of the officers of the Congress and the members of the new Council.

The session was opened by Prof. Beyrich, the President of the last Congress, who, after a brief discourse called upon Dr. Hulke, one of the general secretaries, to read a letter from Prof. Huxley, Honorary President, in which the eminent naturalist regretted that the state of his health would not permit him to attend the session. Sir Douglas Galton pronounced an English speech of welcome on the part of the committee of organization to the geologists of the different countries congratulating them upon the large number of representatives who were present. Professor Capellini thanked the speaker on behalf of the foreign members of the Congress. The report of the council of the last Congress including the list of members of the definitive bureau proposed by it, was received and elected, including one vice-president to represent each country from which delegates to the Congress were present.

Following this came the inaugural address of the President, Prof. Prestwich of Oxford, the Nestor of English geologists. After calling attention to the advantages of such gatherings of geologists coming from all parts of the world, he referred to the objects which were stated as the fundamental work of the Congress at its first session, viz: The uniformity of nomenclature, of classification, and of coloration for geological maps.[1]

The session of the 18th Sept. was consecrated to the discussion of the Cambro-Silurian, that is to say, the classification of the lower Paleozoic. These measures have been studied by different geologists and very important memoirs were presented on them by the English and North American Committees.

In view of the divergent views of the English and American committees representing the countries most directly interested in the subject, and of their adherents in the general

[1]The address of Prof. Prestwich has been separately printed and very largely distributed among geologists of different countries.

membership of the Congress no unanimity and therefore no conclusion was possible, although the discussion was maintained with great temperance and consideration of expression. It was finally unanimously agreed to divide the Paleozoic into three parts, for which the names were not even suggested at this session, it being thought naturally fitting that this matter should form an integral part of the discussion at the meeting in Philadelphia. As part of this discussion was of course the time-honored differences between the adherents of Murchison and Sedgwick, the chiefs of the schools of London and Cambridge, Prof. Lapworth proposed, as a means of accommodating the differences of these two schools, the terms Cambrian, Ordovician and Silurian, giving to each those measures which he first described, entirely removed from the strata of his adversary, and giving a distinctive name to that sequence of beds which were claimed by both of them. Dr. Hicks, representing himself as a disciple of both schools, proposed to the Congress to accept Prof. Lapworth's proposition, and this was supported by Prof. Marr, adjunct professor at Cambridge, and one of the sub-committee on classification, who regarding the question from the paleontological point of view recognized the necessity of three names to distinguish the three divisions or systems. In honor of the distinguished savant Barrande, he proposed that the lower Silurian of Murchison be called Barrandian. This proposal evidently did not find favor with the assembly.

Prof. Lapworth proposed the two terms protozoic and deutozoic to designate the first and second natural divisions of the Paleozoic, corresponding with the distinct epochs observed everywhere over the globe which were called lower Paleozoic (Cambrian, Ordovician, and Silurian), and upper Paleozoic (Devonian, Carboniferous, Permian). Dr. T. Sterry Hunt, who has studied the question carefully, seconded the proposal of Prof. Lapworth. Prof. Gosselet, while approving the term Ordovician rejected that of protozoic and deutozoic in view of the importance which the Devonian system assumes in the Ardennes. Prof. Kayser supported the division proposed by the American Committee and accepted by Prof. Dewalque, of Taconic, Cambrian and Silurian.

There is one phase of the question which is important, in view of the publication of the map of Europe, which will in-

fluence more or less the classification of the whole world. As it is a fact that the primordial fauna was first discovered in North America by Prof. Ebenezer Emmons prior to its discovery by Barrande in Europe, it is just, according to the laws of priority, to concede to America a part of this classification. Furthermore, considered as a paleontological question, the Cambrian of Sedgwick comprises the second fauna which was discovered by this geologist before Murchison extended his investigations to the region which contained it. Therefore, Sedgwick recognized that this fauna was entirely independent of the system of beds which included the Tertiary fauna, or the Silurian, properly so-called.

It was remarkable that although many geologists from North America were present at the Congress, and among them many who were members of the sub-committee of the lower Paleozoic, not one presented himself to sustain these views; on the contrary Mr. Gilbert, of Washington, declared himself indifferent to the choice of names, but insisted that before adopting any system the strata from hitherto unexplored parts of the globe should be examined.

Prof. Otto Torrell declared himself an adherent of the Murchisonian nomenclature. He would propose, in opposition to the preceding speakers, that the term Cambrian be applied to the first fauna of Barrande, the lower fossiliferous beds of Olenellus, and that a special name be given to those lower clastic beds in which up to the present no fossils had been discovered. He rejected the term Ordovician, preferring to designate as lower and upper Silurian the beds above the Cambrian.

Dr. Barrois called attention to the inconvenience of employing words not univocal for these divisions. The univocal terms were evidently preferable and had been recommended by the Bologna Congress and in the report of the secretary on nomenclature.

The Director general of the geological survey of the United Kingdom declared himself an ardent supporter of the classification of Murchison and thought "Ordovician" unnecessary. Prof. Hull, Director of the geological survey of Ireland, espoused the same cause. Mr. Walcott illustrated the stratigraphic succession of the primordial faunas in America. The Cambrian (considering as such the lower system of fossilifer-

ous beds of the lower Paleozoic) inclosed successively three distinct faunas: the lower Olenellus; the middle Paradoxides; and the upper characterized by Dikelocephalus and Olenus. This succession is exactly the same as that observed in Sweden *and proves that the order of the appearance of the series all over the globe in the remotest epochs was the same in Europe and America,* which had not before been so positively demonstrated.

In harmony with a resolution of the Council in regard to the manner of voting, scientific questions were not to be decided by vote, the influence of the predominating number of those members who are natives of the country where the Congress is held being sensibly felt. A committee of seven members was appointed to draw up a sketch of regulations for the voting in future Congresses, and to report them at the last meeting of the Congress of London.

In this session like the following it was permitted to several orators to make their remarks in English, which were promptly and brilliantly rendered into French by Dr. Barrois, one of the Secretaries.

The entire session of Sept. 19, and the greater part of that of the 21st, were devoted to the discussion of the crystalline schists. Important memoirs on this subject had been prepared by Hunt, Heim, Lory, Lehmann, Michael Lévy, Lawson, the geologists of the U. S. Geological Survey, and Lossen, which were printed and bound into a volume which was distributed to all the members of the Congress. Profs. Kinahan and Kilroe, of the geological survey of Ireland, sent also memoirs to the Congress. It is useless to resumé all these memoirs. Prof. Lory resumed the results of his studies of the western Alps. The crystalline schists, which fall into two groups, form a succession of regular and constant mineralogical characters. The upper group is composed of sericite schist, chlorite and amphibolic schists ("pietre verdi" of the Italian geologists). The lower group consists of mica-schists and gneisses, and intercalated concordantly with these beds of cipoline limestones, pure saccharoidal limestones and dolomites. Prof Issel accepts the same views for the maritime Alps.

Mr. Heim opposes entirely the views of the preceding speakers. He considers it premature to divide the schists into stratigraphical sequences based upon these petrographical

characters. He lays stress upon the metamorphism and modifications due to contact, etc.

M. Mattirolo from his investigations of the Western Alps believes that the Permian and Triassic rocks can present the characters of crystalline schists through metamorphism. M. Gosselet attributes to mechanical action the metamorphism of the rocks of the Ardennes.

Prof. Blake cites the rocks of Anglesey which the members of the Congress will visit in a few days, and remarks that a difference should be allowed between the effect of static pressure and dynamic movement which produces false bedding or cleavage. Both effects can be observed at the same point.

Prof. Lapworth supports the principles enunciated by Heim and Lehmann from his studies of the Highlands of Scotland.

Prof. Hull presents a memoir of Prof. Kilroe with illustrations from the rocks of Donegal. He considers that in the effects of metamorphism, it is fundamental to distinguish between the effects of mechanical and hydro-thermal agents. In his opinion mechanical movements might alone facilitate but could not produce secondary combinations.

Dr. T. Sterry Hunt presented in a long and able discourse his crenitic theory. [This theory has been already several times presented to the readers of the "Geologist" and does not need repetition here.] Prof. Renevier rejects the theory which would classify all the crystalline schists among the Archean.

Prof. de Lapparent reminds the speakers that pressure of itself without movement will not produce heat.

Prof. Heim supposes that the heat is produced by successive shocks or tremors similar to those which are observed in ordinary earthquakes. Responding to a remark of Prof. Renevier he says that the trunks of the trees alluded to had not been transformed into gneiss, but were found in beds intercalated in pseudo-gneiss. Lapparent cites schists in Brittany containing trilobites.

Mr. Joseph MacPherson presented the results of his studies of the Archean series in Spain.

Dr. Hicks denied that the general metamorphism of the pre-Cambrian rocks could be explained by pressure and contact and illustrated his remarks by the conclusions to which he had arrived from a study of the geology of Wales.

Prof. Lossen, M. Michael Lévy, Mr. A. C. Lawson, Dr. Geo-

H. Williams and others continued this interesting discussion which, however, according to the rules which the Congress adopted for its government was followed by no vote.

On the 20th the discussion was directed to the limitations of the Tertiary and Quaternary terranes.

Prof Renevier and Dr. Blanford think that the Quaternary should not be considered a group of equal value with Tertiary but should be regarded as a sub-division of the Tertiary.

Prof. de Lapparent, Dr. Frederick Sacco of Tunis, Prof. Gosselet, Prof. Pilar, and Mr. Evans think it important enough to rate independently. Prof. Prestwich while thinking the epoch of importance, as containing man, would call it Plistocene.

During the session of the 21st of Sept. Dr. Hauchecorne presented the first sheets of the geological map of Europe, representing a part of central Europe, comprising a part of Denmark and Sweden, the greater part of Germany, Holland, Belgium and a part of France, including the Ardennes. The map was constructed on a scale of $\frac{1}{1500000}$ and has for principal meridian that of Paris, but also on one of the margins has the longitudes referred to London.

On Saturday the 22d was the concluding session. The committee on the method of voting consisted of Capellini President, de Lapparent Secretary, Blanford, Inostranzeff, Neumayr, T. Sterry Hunt and Zittel. This committee recommended that the vote on any question should be divided into two parts: 1st, that of the members from other countries than that in which the Congress was held, and 2d that of the members who are natives of the country where the Congress happens to be held. If these two votes are accordant the result may be accepted as final. If they disagree it will be considered that the question has not been sufficiently studied, and the resolution will be submitted to another Congress.

At the session of the 19th, Prof. Frazer presented a long list of scientific societies and institutions of higher instruction inviting the Congress to hold its next session in the United States, and others inviting the Congress to select respectively Philadelphia and New York as the place of meeting. Two days later an invitation was received by cable from major Powell for the Congress to meet in Washington. The Council received with the greatest enthusiasm these invitations, which was shared by Profs. Stur and Neumayr in the name of

the geologists from Austro-Hungary, who hoped that the succeeding session—that of 1894—would be held in Vienna.

On the motion of Prof. Capellini the Council decided that a committee consisting of Frazer, Gilbert, Marsh, Newberry, Sterry Hunt and Walcott should constitute a provisional committee, with the addition of the names of Profs. James Hall and J. D. Dana, which committee should select the city where the re-union should take place and name the organizing committee. By unanimous vote the city of Philadelphia was selected.

This unanimous vote received by the Council was presented by the President to the Congress at its session of the 21st September, and approved by acclamation; as likewise was the proposition by the President to send a telegram of thanks to the mayor of Philadelphia.

One of the motives for selecting this city as the seat of the future Congress was that the university of Pennsylvania has resolved to celebrate in 1891 its centenary, on which occasion it will draw thither savants from all parts of the world. Another reason is that there will be at that time a re-union of the International Medical Congress in Washington, and many of the distinguished foreign members of the latter will be invited to participate in the ceremonies of the University, which is one of the five oldest in America and the second in point of equipment in halls, laboratories, and other adjuncts of a great centre of higher instruction. Three millions of dollars additional will be invested in furtherance of its aims. The Provost of the University authorizes Prof. Frazer to offer all the necessary facilities to the Congress for its meeting in the halls of the University. But the principal reason which decided the choice of Philadelphia before the other cities of the Union was, that the idea of assembling an international Geological Congress took shape in 1876 during the celebration of the centenary of the independence of the United States by the International Exposition at Philadelphia. The 'comité fondateur' of the Congress was appointed by the American Association for the Advancement of Science at its meeting in Buffalo during the before-mentioned year, and received the official name which the American Committee (its direct continuation) has retained at all subsequent Congresses, of "Comité fondateur de Philadelphia." The invitation was signed by the mayor of the city; the president or chief officer of all the principal institutions of

science and education; the principal executive officers of the city; the select and common councils; the judges of the courts; the military officers of the U. S., resident in the city; the presidents of the banks, of the great railways, of the large industrial institutions; by large numbers of the most eminent lawyers, merchants, and in short by representatives of the most important activities of the city. With the patriotic and liberal spirit of Americans, Profs. T. Sterry Hunt and Frazer declared that they hoped to be able to effect a reduction of the expense of the voyage to America and back to Europe to half the ordinary cost, as was done for the members of the British Association for the Advancement of science during its session in Montreal in 1884. Further, as three of the presidents of the great trans-continental railway lines had joined in the invitations, it was probable that excursions to the Rocky mountains, to Canada, to the great lakes, and to the south would be arranged for the foreign members at greatly reduced rates if not almost gratuitously.

The last session of the Council had a long discussion relative to organizing the international committee on nomenclature, the old one having ceased to exist from the opening of the London Congress. Prof. Cappellini put the question whether it should be newly nominated, preserving the functions which it previously had, or whether it should be dissolved, or whether it should be changed so as to possess only some of its previous functions.

Prof. Renevier was of the opinion that the functions of the Congress should terminate and that the Congress should name committee-men who should discuss by letter certain questions and seek to procure harmony. It was not necessary to preserve a large international committee. M. Stefanescu was opposed both to the dissolution of the old committee and to the propositions of M. Renevier, as in the case of the acceptance of them the committee would lose its international character. Mr. Evans thought that the best practical means was for every nation to name a committee and for these committees to discuss the matters by correspondence. Prof. Gosselet thought that a committee on nomenclature ought to be retained and that each nation should have one vote in this committee. M. Issel thought that it was very important for the professors of geology if the Congress should indicate to them the road to

pursue. From the point of view of education a uniform system of nomenclature was necessary, and in support of his view he cited the enormous progress of chemistry due in great measure to the adoption of general rules of nomenclature. Prof. Zittel was of the opinion that it was very useful to have a committee on nomenclature, since the existing committee had accomplished such excellent work, but that the committee should occupy itself with general questions and not discuss particular affairs.

In the end the proposition of Mr. Evans was approved to name anew a committee on nomenclature like the one now existing, its members to organize in their respective countries national committees to study these questions and to communicate with each other by correspondence. By an amendment of Prof. de Lapparent all geological societies, and all the geological institutes and surveys existing were included in the resolution. After a short discussion the Council proposed the following list of members which should compose the international committee of nomenclature and this list was approved unanimously by the Congress.

Germany	Prof. Zittel.
Australia	Mr. Liversidge.
Austria	Mr. Neumayr.
Belgium	Mr. Dewalque.
Bulgaria	Mr. Zlatarski.
Canada	Dr. Robt. Bell.
Denmark	M. Johnstrupp.
United States	Prof. James Hall.
France	Prof. de Lapparent.
Great Britain	T. McKenney Hughes.
Spain	Vilanova y Piera.
Hungary	Szabo.
India	Blanford.
Italy	Capellini.
Mexico	Castillo.
Norway	Kjerulf.
Holland	Calker.
Portugal	Delgado.
Argentine Republic	Brackenbusch.
Roumania	Stefanescu.
Russia	Inostranzeff.
Sweden	Torell.
Switzerland	Renevier.

By resolution of Prof. de Lapparent the President and Secretary of the old committee became the President and Secretary of this one.

Prof. Prestwich then resuméd in a few words the work which the Congress had accomplished. Resolutions of thanks were then

passed to the senate of the University of London and to all those who had assisted the Congress in its work, &c. Prof. Capellini in a few graceful phrases expressed the gratification of the foreign members and regretted the absence, owing to sickness, of Prof. Huxley. The President in accordance with a vote then passed declared the Congress adjourned.

In the remaining part of his book Col. Delgado describes the collections both of the Congress itself and of the museums visited by its members, the excursions, &c., and concludes with a few words of faith in the utility of the Congress and appreciation for the labors of the English committee.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

The rock-scorings of the great ice invasions. By T. C. CHAMBERLIN. Pages 147-248. (Accompanying the seventh annual report of the director of the U. S. geological survey). Fifty figures, mostly reproduced from photographs, are inserted in the text, illustrating various conditions in glacial erosion and striation, both of the bed rocks and of the boulders and pebbles in the drift. Very instructive and extraordinary glacial markings, supplying about a quarter part of these illustrations, are found on the Corniferous limestone surface of Kelly's island in the west part of lake Erie. There the Striæ in one place follow the winding channel of a water-course that is worn several feet deep in the rock; and specimens of glacially fluted limestone are obtained which resemble the massive mouldings of architecture. Striæ have been recorded in about 2,500 localities upon the glaciated area of the United States, being in some districts too numerous for representation on the accompanying map; while in other districts, some of which, as notably the Adirondack mountain group, doubtless have abundant glacial markings, no observations of them have been obtained.

The geographical distribution and topographical relations of the striæ, especially the varying positions of the striated surfaces, and the influence of topography as affecting the distribution of striæ are considered in much detail; and the evidence points indubitably to the grinding and scoring action of a vast sheet of land-ice moving radially outward from central areas of maximum accumulation. Amplifying a simile of professor Newberry, the author remarks: "The glacialist should be able to distinguish with as much certainty the traces of a glacier or of an iceberg or ice-floe as the hunter the track of a bear or a moose or a serpent. A glacier may be likened to an ophidian, crawling prone; an iceberg, to a digitigrade, walking on its toes; an ice-floe, to a semiplantigrade, setting down the edge of its foot."

Intersecting striæ on the same rock surface, and adjacent surfaces

diversely striated, are referable, for the great majority of cases, to deflections of the glacial currents near the border of the ice-sheet during its recession, belonging thus to a single glacial epoch rather than to successive ice-sheets separated by an interglacial epoch. But in some instances, notably in northern Indiana, president Chamberlin has observed crossing systems of striæ that quite certainly belong to different epochs. There are also in the same district two sets of moraines, which complete the demonstration of a movement from the east that over-rode territory previously invaded from the north.

Considering the abrading and scoring action of the ice-sheet, it is compared to a plow, a file, and a sled; and the author concludes that much the larger part of the work of striation and polishing was the result of action analogous to that of the file. The simplest form of striation, consisting of fine, hair-like lines, is attributed mainly to sand and silt caught between the larger erratics and the bed-rock over which they were being forced. Where larger, obdurate particles were entrapped, deeper scorings were made. Under this view the abrupt origin and disappearance of some of the striæ are quite readily accounted for. When a particle was overtaken by a slab or a flat-bottomed boulder embedded in the ice, it was forced strongly into the under surface and kept in action as a graver until the boulder passed over it, unless sooner worn out or crushed, when it was abruptly freed from the exceptional pressure.

The manifold phases of glacial planation, embossment, grooving, striation and polishing are very fully discussed in this paper, as to their characteristics, their mode of origin, and their significance respecting the history of the glacial epoch; and the map displays the limits of the drift-covered area across the United States, and the courses of the glacial striæ.

Die Stämme des Thierreichs. Von M. Neumayr. Erster Band: Wirbellose Thiere, 1889. The first volume of this remarkable work has recently appeared. It is a large octavo comprising over 600 pages, illustrated by 192 cuts, and is the outcome of more than a quarter of a century's work and observation. The first one hundred and fifty pages are devoted to the general discussion of animal morphology and evolution. The chapters on the various sub-kingdoms are each introduced by a full consideration of the leading anatomical features after which is a more detailed notice of the sub-groups. The Protozoa occupy approximately 55 pages; the Cœlenterata, 140 pages; Echinodermata, 150 pages, and the Vermes 95 pages. The part relating to the echinoderms is particularly interesting and suggestive. The obscure and curious group of cystids appears to be of considerable more importance than has hitherto been commonly regarded. The genetic relations of the Echinodermata are thus expressed:

Crinoids. Echinoids. Stellerids.

Cystids.

The Crinoidea are sub-divided into two great groups, *Epascocrinen* and *Hypascocrinen;* according to whether the mouth and food grooves are open or closed. The division of the Crinoidea based upon this character has recently been shown to be untenable and has been abandoned. The second volume of this important work will be issued shortly. C. R. K.

The Archean Geology of the region northwest of lake Superior. By ANDREW C. LAWSON. (In *Etudes sur les schistes cristallins;* published by the *Comite d'organization* of the late London session of the International Congress of Geologists, London 1888.) In this paper are given concisely the main points reached by the author in his late studies in the region mentioned, for the Canadian geological survey. The rocks of the Archean he divides into upper and lower divisions, the lower being the gneisses and syenites of the Laurentian, and the upper the crystalline schists and the sericitic schists and graywackes. He regards the Laurentian as the ancient floor on which the upper Archean was deposited, but which has since been fused and rendered "magmatic," so as to penetrate fissures and overflow considerable areas of the upper Archean; that primarily an older rock it is, in its present condition and position, a younger rock than the schists. The upper Archean he describes as a very distinctly stratiform assemblage of rocks, partly of detrital sediments and partly of volcanic ejectamenta, separable into Coutchiching, the crystalline schists proper, and Keewatin, or the sericitic schist group. The former were laid down in a period of extreme quiescence, but the opening of the Keewatin "appears to have been the beginning of a widespread volcanic activity which lasted throughout." There is apparent conformity between the two series, according to the author, but owing to the profound contrast in petrographic characters he considers that the line of demarkation between them represents an historical break which is of the nature of an unconformity.

As to the nature of the contact between the upper Archean schists and the lower Archean gneiss, the author recognizes the difficulty which geologists will find in accepting his hypothesis that the gneiss is both older and younger than the schists. "There is now no trace of that floor, in the condition in which it must have been when other rocks were laid upon it." * * * "On the contrary it presents the most convincing evidence of bearing the same relation, subject to certain qualifications, to the upper Archean that an eruptive rock bears to the strata through which it breaks." The author conceives that the Laurentian sediments were depressed, after the accumulation of the upper Archean, so as to come within the fusion plane of hydro-thermal agents, and that they were in this magmatic condition not only re-crystallized but were extruded through the upper Archean, which the author supposes did not experience this fusion, or if it did the original rock was converted to Laurentian hornblende-syenite (if from the Keewatin) or Laurentian biotite-granite-gneiss (if from the sediments of the Coutchiching).

Mr. Lawson meets the natural objection, that in the original Laurentian are quartzytes and limestones, whose general characters and stratiform arrangement indicate that they are simply altered sediments, by the suggestion that these will be found on careful examination to bear the same relation to the great bulk of the granitoid gneisses that the upper Archean bears to the lower in the region northwest of lake Superior, i. e., that they are simply included, isolated or disrupted portions of beds that normally belong above the gneiss, that have been covered by overflow.

There are several points in Mr. Lawson's general scheme that are new, and some that at another time will be compared with results that have been reached by the Minnesota geological survey, with which they do not entirely agree.

CORRESPONDENCE.

The Taconic in the Salt Range of Punjab (India). Two letters which I have just received from India and England establish beyond any doubt the existence of the primordial fauna in the Salt Range mountains; adding a third area of Taconic rocks in Asia (one in China and another in Siberia). Mr. A. B. Wynne in his very remarkable memoir: "Geology of the Salt Range of Punjab" 1878 *Mem. Geol. Surv. India*, vol. xiv, Calcutta) at p.p. 68 and 86, refers some beds containing *Obolus* and some other earliest forms of brachiopoda to the Silurian. The fossils were determined by that excellent and much lamented paleontologist and geologist, the late Dr. F. Stoliczka.

In 1878, Dr. A. Waagen, the successor of Stoliczka as paleontologist of the geological survey of India, expressed an opinion entirely different, regarding the "boulder or *Obolus* beds" as Lower Carboniferous, saying that the "small brachiopod most nearly allied to *Obolus*, from which Wynne has concluded prematurely that the beds are Silurian" was not well determined. (See "geographical distribution of fossil organisms in India," p. 276 in Rec. Geol. Surv. India, vol. xi, Calcutta.)

Following his view Dr. Waagen in the introduction of his great work on "the Salt Range fossils," p. 3, Calcutta, 1879, places the "*Obolus* beds" in his "*Productus* limestone" of the Carboniferous system, and in order to support this new departure he did not hesitate to create in 1885 four new genera. *Neobolus*, which does not possess any real biological difference from the genus *Obolus*, *Schizopholis*, *Davidsonella*, and *Discinolepsis;* and finally he described also two new *Lingula*. All that little brachiopod fauna is figured and described at great length in his "Productus-limestone fossils," at p. p. 748-770. All that fauna, five genera and eight species, composed exclusively of Taconic forms of brachiopoda, most characteristic of the primordial brachiopoda of North America and Europe is placed, without hesitation by Dr. Waagen, in the Carboniferous system, third division, at the base of

what he calls the "Magnesian sandstone group" as his "Neobolus beds" instead of the "Obolus beds" of Wynne and Stoliczka; saying that the term "*Productus limestone*" applied to the whole series "must be now considered as a synonym of *Carboniferous*." (Preface p. vii; Prague, 1887.) In the same preface, which has been issued at the end of the "Salt Range fossils," Calcutta, 1887, *Mem. Geol. Surv., India*, series xiii, 1 and 7, Dr. Waagen refers the *conulariæ* of the "speckled sandstone" or the Cretaceous "Olive group" of Wynne, also to the Carboniferous system, placing them above his "Neobolus beds" and below the mountain limestone fauna. That other most extraordinary inexact paleontologieal interpretation and view, was not accepted by all the practical geologists of the survey, and it was opposed, as well as his idea of the "Obollus beds" being Carboniferous, by Messrs. Medlicott, Wynne, Warth, and Richard D. Oldham. Dr. Waagen did go so far in that singular preface as to speak of "animosity" and "contempt" for his geological ages of the strata of the Salt Range; because all these good and original investigators disagreed with him. These complaints of Dr. Waagen are not well founded; he explored himself once the Salt Range mountains in company with Mr. Wynne, and he saw the "Obolus beds" lying under and in unconformity with the Carboniferous; and if he had adopted Stoliczka's determination of primordial fossils, he would have easily considered his extraordinary confusion of placing a whole system of strata in the Carboniferous, with which it has absolutely nothing in common.

A most important discovery has just come to light, which puts an end to the great errors held with such pertinacity during the last ten years by Dr. Waagen. The indefatigable Dr. Worth, the discoverer of the primordial brachiopod fauna and of *Conularia*, has found some trilobites in the "Obolus beds." One of them is a *Conocephalites* which Dr. Waagen himself says is very nearly related, if not identical with *Conoc ephalites formosus* Hartt, from the St. John group of New Brunswick, North America; and another trilobite is perhaps an *Olenus*, or more likely a *Dorypyge*. There is no question that such form of trilobites can not be of Carboniferous age; they are decidedly Lower Paleozoic and belong to the Middle Taconic. The truth is that Dr. Waagen, against stratigraphy, against lithology, and what is worse for a paleontologist, against paleontology, has referred and inclosed in his Carboniferous system of Punjab: first, the primordial fauna and the Taconic system, and second, the "Olive group" of the Nummulitic age; two errors so enormous that they remind one of the transfer of the primordial fauna above the second and even the third by certain American geologists; and the enclosing of the Trias, Jurassic and Neocomian of Texas and New Mexico in the Dakota or marly chalk of Europe.

We have these examples as well in Asia as in North America of the absolute necessity to check the works of a certain class of paleontologists, too apt to err in following preconceived ideas. An exact, careful and sharply delineated stratigraphy made by practical observ-

ers trained by long researches in the field, must always come first; and all the hasty synchronism and equivalency of faunæ be carefully avoided. A severe control of all the facts by able investigators must be resorted to before jumping at conclusions. These remarks are more and more necessary in order to keep constantly on our guard against the too numerous confusions introduced anomalously as a regular crop of errors by the special class of paleontologists. Of course paleontologists like Barrande, Emmons, Agassiz, Edward Forbes, Alcide d'Orbigny, Deshayes, d'Koninck, de Verneuil, instead of introducing errors, have been the originators of great truths, and have contributed immensely to the progress of stratigraphy and paleontology. In my long experience in both hemispheres I have seen several examples of how some paleontologists easily created new genera, or identified fossils, straining the plain paleontological evidence; and I can not insist too much on putting younger practical geologists on their guard not to accept authorities without a severe control.

The last contradiction and confusion has just been called to my attention; it is contained in Mr. Walcott's paper: "Stratigraphic position of the Olenellus fauna in North America and Europe." (*Amer. Jr. Sc.*, May, 1889, p. 374.) The author says: "The relative position of the Middle and Lower Cambrian fauna is *now* changed, the Paradoxides zone being removed to the Middle, and the Olenellus zone to the Lower Division;" a chasse-croisée to which we have been accustomed. For Mr. Walcott there is only one horizon of Olenellus in Europe and North America, and in his hasty paleontological classification he had put together all the fossils of the Georgia group with those of Manuel brook, Conception bay, Newfoundland, an uncalled for confusion, showing how Mr. Walcott differs in his method of dealing with classification of stratigraphical facts and paleontological determination of fossils from Mr. Mathew and myself. I refer to the two papers lately issued: "On the classification of the Cambrian rocks in Acadia No. 2," by G. F. Mathew; and "Olenellus beds in Scandinavia and North America" contained in my paper, "Canadian classification for the province of Quebec," in which a move in the right direction has been fairly started. I hope to be able to publish before long a paper on "Olenellus and Paradoxides in both hemispheres," in which I shall treat at length of the stratigraphy and synchronism of the different groups of the middle Taconic.

27 May 1889, Cambridge, Mass. JULES MARCOU.

PERSONAL AND SCIENTIFIC NEWS.

DR. T. STERRY HUNT has partially recovered his health; has returned from Florida and is at the home of his friend James Douglas at Spuyten Duyvil, N. Y.

DR. PERSIFOR FRAZER, ONE OF THE EDITORS OF THIS JOURNAL,

who left Philadelphia May 16th for the city of Mexico, for the purpose of some scientific work there has returned after an absence of about a month.

ACCORDING TO J. B. TYRRELL, in the *Canadian Record of Science*, the gypsum deposits of Manitoba, are practically of about the age of the Onondaga formation of New York and western Ontario.

THE POSTHUMOUS PUBLICATION of Prof. A. H. Worthen's, volume VIII, of the report of the Illinois geological survey, is an event, which geologists will eagerly welcome. Chapter I, of which advance sheets have appeared, edited by Dr. Josua Lindahl, is devoted to the drift deposits of Illinois, and gives expression to views unfavorable to the glacial theory of Agassiz.

ACCORDING TO MR. JAMES M. SWANK the year of 1888 witnessed the greatest production of iron ore and of pig iron in the history of the United States, the latter amounting to 7,268,507 tons and the former to 12,050,000 tons. At the same time there was a shrinkage in the production of Bessemer steel rails from 2,101,904 tons in 1887, to 1.386,278 tons in 1888, a decrease of 715,626 tons, which is greater than the total product of the United States in 1879, when we made 610,692 gross tons. From the Lake Superior region were shipped 5,023,279 gross tons of ore in 1888; of this the Marquette range supplied 1,921,-525 tons, the Gogebic range 7,424,762 tons, the Menominee range 1,165,039 tons, and the Vermilion range 511,953 tons.

AN ALASKAN GLACIER. The most accurate information yet obtained concerning these glaciers is that gathered by Mr. William P. Blake in 1863. According to him, "there are four large glaciers and several smaller ones visible within a distance of sixty or seventy miles from the mouth" of the river. The second of these larger ones has attracted most attention. This "sweeps grandly out into the valley from an opening between high mountains from a source that is not visible. It ends at the level of the river in an irregular bluff of ice, a mile and a half or two miles in length, and about one hundred and fifty feet high. Two or more terminal moraines protect it from the direct action of the stream. What at first appeared as a range of ordinary hills along the river, proved on landing to be an ancient terminal moraine, crescent-shaped and covered with a forest. It extends the full length of the front of the glacier."

This glacier has never been fully explored. A number of years since, a party of Russian officers attempted its exploration, and were never heard from again. Mr. Blake reports that, as usual with receding glaciers, a considerable portion of the front as it spreads out in the valley is so covered with bowlders, gravel, and mud that it is difficult to tell where the glacier really ends. But from the valley to the higher land it rises in precipitous, irregular, stair-like blocks, with smooth

sides, and so large that it was impossible to surmount them with the ordinary equipment of explorers. The glacier is estimated to be about forty miles long.—PROF. G. F. WRIGHT, *in the Popular Science Monthly for June.*

APROPOS THE MENTION OF THE CLASSIFICATION OF THE CRINOIDEA by Neumayr in his Stämme des Thierreichs, another note may not be impertinent. The recent investigations among fossil crinoids have brought to light many features of great morphological import, rendering necessary some modifications in the existing systematic arrangement. With this in view there will shortly appear, it is understood, a joint revised classification of the class, by Messrs. Wachsmuth and Springer, and Dr. P. H. Carpenter of England. The paper will be issued simultaneously in this country and Europe.

THE MARIETTA SCIENTIFIC ASSOCIATION was recently organized at Marietta, Ohio, for the promotion of scientific inquiry and the investigation of all scientific matters that may be of interest in the immediate vicinity of Marietta. It is tributary to Marietta college, and its collections will be deposited in the college museum. The president is T. D. Biscoe, and the corresponding secretary is C. K. Wells.

PROF. G. FREDERICK WRIGHT, OF OBERLIN, recently made a cursory examination of some parts of the gorge of the Mississippi river between Minneapolis and Fort Snelling, for the purpose of noting personally the points of evidence in the discussion of the recession of the falls of St. Anthony bearing upon the date of the glacial epoch, as brought out by Prof. Winchell in vol. II, of the final report of the Minnesota survey.

THE CIRCULAR OF THE PERMANENT SECRETARY of the Toronto meeting of the American Association for the Advancement of Science has been issued. The session will begin August 27th at noon, by a meeting of the Council. The first general session will begin at ten o'clock on the 28th. The American Geological Society will hold a meeting at Toronto, Aug. 28th and 29th.

SOMETIME AGO DR. STEPHEN BOWERS, OF VENTURA, CALIFORNIA reported that, in grading the streets of that city, some teeth and bones had been found which he supposed were those of a fossil llama. These teeth, together with some other fossils from Ventura county, have more recently been examined by Dr. Lorenzo G. Yates, of Santa Barbara, and he pronounces them cusps of the tooth of a mastodon. This decision will probably be accepted by geologists owing to the well-known long study that Dr. Yates has given the subject of the mastodon, his remains and former distribution, in California. Remains of the mastodon have been found in so many places on the Pacific slope that it is plain that he roamed extensively over the plains of California.

DAVID DALE OWEN.

THE

AMERICAN GEOLOGIST

VOL. IV. AUGUST, 1889. No. 2

SKETCH OF THE LIFE OF DAVID DALE OWEN, M. D.

His ancestry, birth, education and marriage. Dr. D. D. Owen's father was Robert Owen, the philanthropist, celebrated for his coöperative experiments, first in Scotland, and, later, at New Harmony, Indiana. Dr. Owen's mother, the eldest daughter of David Dale, merchant and Lord Provost of Glasgow, Scotland, was married to Robert Owen in 1797, and David Dale Owen, their third son who lived to maturity, was born at Braxfield House, near New Lanark, Scotland, June 24th, 1807.

His early training, under a private tutor, embraced chiefly instruction in the English branches, the rudiments of Latin, and a course of architectural drawing. At the same time a portion of each day was devoted to acquiring facility in the use of carpenters' tools, materials and instruction being furnished at the extensive mechanical department connected with the large cotton manufacturing establishment of Dr. Owen's father. Later the Lanark academy, or grammar school, furnished additional classical training for a college course. Robert Owen, while traveling on the continent of Europe, had visited the celebrated educational institution of Emmanuel Fellenberg, near Berne, Switzerland, and was so much pleased with the system pursued, equal attention being directed to the physical, moral and intellectual development, that he sent his

oldest son, Robert Dale Owen, there, (subsequently in the U. S. the author of several works, member of Congress and U. S. Minister at Naples) accompanied by his next brother, William who a few years after his emigration to the United States, died at New Harmony, Indiana. After they returned from their three-year course, Dr. D. D. Owen and his younger brother Richard Owen were sent there (in 1824) and remained also three years.

The *physical* training at this institution, consisted in daily gymnastics, athletic games, weekly excursions, and in vacations, spent in traveling on foot with knapsack and "alpen-stock," averaging about twenty miles daily, while traversing each year a new portion of Switzerland. The *moral* education consisted in the formation of class-circles, for mutual improvement, each presided over by a member of the senior class, and meeting regularly under their leader. These reported to the "general assembly" which was convened at intervals by Mr. Fellenberg, who, besides, met all the students every evening for a brief period of opening prayer and invitation to any one who desired to make an observation, either bearing on his own case or that of a classmate.

The *intellectual* course for the more advanced classes, was partly optional, and Dr. Owen and brother selected chemistry, drawing, and modern languages, in addition to the usual mathematical and literary course; on returning to Scotland, Sept. 1826, they entered the chemical and physical classes of Dr. Andrew Ure, lecturer at the Andersonian Institution, in Glasgow, where their mother then resided; Robert Owen having meanwhile emigrated to the United States in order to test his social experiment at New Harmony, Indiana. For that place Dr. Owen and brother left Liverpool, in a sailing vessel, Nov. 1827, passing through the West India Islands, and reaching New Orleans about the last of December; thence arriving by steamer at New Harmony, early in January, 1828. Here, with the chemical appliances which had been brought from Glasgow (purchased when visiting the chemical and glass works of that city), the experiments made by Dr. Ure, and which had been repeated each day at home in Glasgow, were again reviewed, until 1831-2. Up to this time Dr. D. D. Owen and his brother, Richard Owen (who afterwards for nine years filled the chair of Nat. Science in the Western Military Institute

and, after serving nearly three years as colonel in the federal army, occupied for 15 years a similar chair in the Indiana State University) had never been separated a single day; and it is from the latter reliable source that the chief details of the early life of Dr. Owen have been derived.

In 1828, Dr. Owen on arrival in the United States declared his intention of becoming a citizen; but in 1831, in order to further qualify himself in chemistry and geology, he again sailed for Europe and, in company with the late Prof. Henry D. Rogers, both of them making their home at the house of Robert Owen, attended the lectures of Dr. Turner, at the London University. Returning in the Autumn of 1832, Dr. Owen narrowly escaped falling a victim to Asiatic cholera, which at that period had reached the western portions of the United States. After his recovery, he commenced the study of medicine at the Ohio Medical College, in Cincinnati, with a view of improving himself especially in anatomy and physiology, as essential aids in the study of paleontology.

During the summers of these years, Alexander Maclure brother of the noted geologist, William Maclure, having administered on that estate, engaged Dr. Owen to arrange the very extensive collection of minerals and fossils made by his brother during his exploratory travels, in Europe, the United States and West Indies. From this collection, Dr. Owen was to distribute specific suites to the indicated schools and colleges. This duty he performed. He was to retain the residue, as the nucleus of a museum. To this latter Dr. Owen subsequently added largely, by purchase from Dr. Krantz of Germany, illustrative fossils of every period; among others an Ichthyosaurus, from the Lias of Wurtemberg, larger than the one in the British museum. Another interesting and valuable specimen was a nearly complete skeleton of a gigantic megatheroid animal (the Megalonyx) which he exhumed near Henderson, Kentucky. The entire collection some years after Dr. Owen's death was purchased by the Indiana University, and unfortunately nearly all consumed by fire, when the new university building, including the Museum, Laboratory and Library, was destroyed.

Dr. Owen, after graduating M. D. in the spring of 1836, spent one summer in accompanying on a state survey, Dr. Gerard Troost, state geologist of Tennessee, a former resident of New

Harmony. This field work was undertaken by Dr. Owen at his own expense for the sake of preparatory practice in field geology. On the 23d of March, 1837, Dr. D. D. Owen was united in marriage to Caroline C. Neef, third daughter of Joseph Neef, formerly coadjùtor of Pestalozzi, in his educational establishments at Yverdun and Burgdorf castle, Switzerland.

Dr. D. D. Owen's geological surveys, arranged chronologically.

1. Immediately after Dr. Owen's marriage he commenced his labors as state geologist of Indiana, having been appointed to that position by the state board of agriculture. His preliminary reconnoissance, made during the years 1837 and 1838, was published in an 8vo vol. of 133 pp. and republished in 1859. Geology being in 1838 but little known to our western people a brief introductory exposition of the leading formations was given in the report; and then attention was directed to the coal fields, iron ores and building stones of Indiana, in all of which the State is abundantly rich.

2. During the survey the Hon. James Whitcomb, the governor of Indiana, had ample opportunity of becoming acquainted with Dr. Owen's qualifications, so that when, as commissioner of the land office, Washington, he was directed by Congress, through Hon. Levi Woodbury, Sec. of the Treas., to have a survey made of the Dubuque and Mineral Point districts of Wisconsin and Iowa, comprising 11,000 square miles of the N. W. territory, in order to reserve from sale those sections found to contain mineral wealth, he selected, as the director of that examination, Dr. D. D. Owen. In order that the report might be made within the required time it became necessary to organize a large corps. The difficulties attendant upon this work can best be appreciated by the perusal of an extract from his report of 191 pages made April 2, 1840, to the commissioner of the general land office.

After showing the requirements, Dr. Owen says: I therefore immediately commenced engaging sub-agents and assistants, and proceeded to St. Louis; there (at my own expense, to be repaid to me out of the per diem of the men employed) I laid in about three thousand dollars worth of provisions and camp furniture, including tents, which I caused to be made for the accommodation of the whole expedition; and in one month from the day I received my commission and instructions

(to-wit, on the 17 Sept.) I had reached the mouth of Rock river; engaged one hundred and thirty-nine sub-agents and assistants; instructed my sub-agents in such elementary principles of geology as were necessary to the performance of the duties required of them; supplied them with simple mineralogical tests, with the application of which they were made acquainted; organized twenty-four working corps, furnished each with skeleton maps of the townships assigned to them for examination and placed the whole at the points where their labors commenced, all along the line of the western half of the territory to be examined. Thence the expedition proceeded northward, each corps required, on the average, to overrun and examine thirty quarter sections daily, and to report to myself on fixed days at regularly appointed stations: to receive which reports and to examine the country in person, I crossed the district under examination, in an oblique direction, eleven times in the course of the survey. Where appearances of particular interest presented themselves I either diverged from my route in order to bestow on them a more minute and thorough examination, or when time did not permit this I instructed Dr. John Locke, of Cincinnati (formerly of the geological corps of Ohio, and at present Prof. of Chem. in the Medical College of Ohio) whose valuable services I had been fortunate enough to engage on this expedition, to inspect these in my stead."

3. The above work having been completed to the satisfaction of the department, and having demonstrated the enterprise and energy of Dr. Owen, he was appointed in 1847 U. S. Geologist and directed to make a survey of the Chippewa land district. The Preliminary Report made in 1848 to the Hon. R. M. Young, then commissioner of the land office, occupies 134 8vo pp., besides presenting 323 lithographs from Dr. Owen's sketches, and numerous maps, diagrams, &c.

4. The above preliminary reconnoissance was by instruction from Washington extended to a more full survey of the N. W. territory, embracing chiefly Wisconsin, Iowa and Minnesota, which occupied five years of field work, and a final year of laboratory and office work, being then continued from 1847 to 1852 both inclusive. The full report in manuscript having been approved, Congress made a large appropriation for its printing and illustration in a high style of art, entrust-

ing Dr. Owen with the entire detail. Considerable saving was made by inviting competition in the various departments of printing, lithographing, engraving on steel and wood. In this report of 638 quarto pages, besides the numerous maps, diagrams, &c., many of the illustrations are from the original drawings of Dr. Owen, who had great facility in sketching. The wood-cuts in the body of the work, and some diagrams are from sketches made by his brother, Prof. Richard Owen, who accompanied Dr. Norwood in the survey of the north shore of lake Superior in 1849, taking also the barometrical and thermometrical observations. The other assistants in this N. W. survey were Drs. Shumard and Litton of St. Louis, Col. C. Whittlesey of Cleveland, O., Drs. John Evans and B. F. Meek of Washington, Messrs. B. C. Macy, Henry Pratton, George Warren and John Beale of New Harmony. Dr. Leidy of Philadelphia, described the mammalian and some other fossils. In the publication of this work Dr. Owen, for the first time, brought the medal-ruling style of engraving to bear on fossil specimens. Besides Ammonites and other figures, the large Inoceramus from Nebraska, medal-ruled on steel from the original specimen, is a magnificent illustration of the excellence of that style, thus applied.

5. In April 1854 Dr. D. D. Owen was selected by governor Powell, of Kentucky, as state geologist and continued to occupy that position for five years. He published the results of this survey from time to time, finally completing four large 8vo volumes, with maps and illustrations, the last volume embracing over 600 pages. In this survey and subsequently in that of Arkansas, Mr. E. T. Cox then of New Harmony and now of New York, was Dr. Owen's principal assistant. The chemical work and report were made by Dr. Robt. Peter of Lexington, Ky.

6. In October 1857, when nearing the completion of his Kentucky survey, Dr. Owen accepted the position of state geologist of Arkansas, tendered him by governor Conway. This gentleman afforded Dr. Owen every facility, and between them there always existed the most cordial good feeling. In 1860 the civil war already threatened, and postal communication between the north and south was considerably interrupted, when the work for the second volume of the Arkansas report had been about completed and Dr. Owen had died; but gov-

ernor Conway made every effort, and succeeded, in sending safely several thousand dollars due from the appropriation, and required for the publication of the second volume, a duty undertaken by Prof. Richard Owen, as administrator at the request of the family of Dr. D. D. Owen, he having dictated portions of his report up to within two or three days of his death and having given full instructions regarding the details of publication. The chemical assistant in this survey was Dr. Elderhorst, author of a work on the blowpipe, a former graduate of VanRensselaer Institute, Troy, N. Y.

7. In 1859 Dr. D. D. Owen accepted the appointment, a second time offered him, of state geologist of Indiana, with the understanding that the work should be executed by his brother, Dr. Richard Owen, who had then, in view of the impending crisis, resigned his professorship at Nashville, Tenn. The results of these two years' survey were embodied in a report comprising 368 8vo pages, with wood-cuts, diagrams, etc., by Dr. Richard Owen, who after his brother's decease had been appointed state geologist. The last of this report was read by him in camp, he having entered the federal service as lieutenant-colonel of the 15th Indiana volunteers. The assistants in this survey were Prof. Leo Lesquereux, for field examination, and Dr. Robt. Peter, for laboratory work.

Personal characteristics, death, family left.

A remarkably prominent feature in Dr. Owen's lifework was his indefatigable perseverance, even under great difficulties. While on the Red river of the North with a Canadian voyageur, the latter permitted his fowling piece, used for procuring game, to be discharged in such a manner as to lodge a number of shot in Dr. Owen's shoulder. But he did not permit the accident to delay him an hour. Again, although he found the Arkansas summer surveys, often made in the rich malarial bottoms, highly detrimental to health, bringing him home in the autumn with a hue denoting strong malarial derangement of the liver, he not only persevered in the surveys, but continued his laboratory winter work usually until midnight; and, as remarked above, while suffering acutely during his last illness, dictated the closing portions of his Arkansas report until within 48 hours of his death. His skill as an artist enabled him, besides leaving some good portraits in oil of members of his family, richly to illustrate his reports. He

also transmitted to London on canvas in distemper, views of the fossil Sigillaria found erect in situ 12 miles from New Harmony. These drawings and the description were presented by Sir Roderick Murchison at a meeting of the British Association for the Advancement of Science. Dr. Owen subsequently conducted Sir Chas. Lyell to the locality during his second visit to the United States, while his guest at New Harmony. It is worthy of note that the early surroundings of Dr. Owen were calculated to promote and strengthen this inherent artistic taste and skill. The scenery amid which he was born included, within a radius of a few miles, several waterfalls, yearly visited by thousands of travelers, the noted Cartland crags, Wallace's cave, and other scenery introduced by Sir Walter Scott in some of his romances; besides, within a short distance, the classical ground described in the "Lady of the Lake," the Trossacks, Ellen's Isle and Loch Lomond; with Ben Lomond not far distant. which mountain Dr. Owen ascended during his travels in the Highlands of Scotland; a fitting preparation for subsequent ascents in Switzerland to a hight on several occasions of over 9,000 feet.

Dr. Owen's amiable simplicity and integrity of purpose were remarkable; his kindness and liberality noted. His fondness for chemistry and skill in that department induced him to build at a cost of $10,000 a laboratory fully equipped in every respect; serving as a fine specimen of his good taste in architecture; which was also further evinced by artistic design which he furnished for the Smithsonian buildings. He also tested great varieties of building stone, before the selection of material was made for that institution.

The unrelaxed strain upon the physical and mental powers, of which the above brief statements may serve to give some idea, resulted in undermining an originally good constitution. Malarial fever complicated with rheumatic attacks, which threatened that great internal muscular organ the heart, terminated Dr. Owen's career of usefulness. He left a widow, two sons and two daughters, all of whom survive, besides 12 grandchildren.

Dr. Owen had enjoyed his laboratory only a year or two when he was called from his unremitting labors to his eternal rest, November 13th 1860, leaving an unsullied reputation for conscientious scientific work, and causing his many warm friends to mourn their sad bereavement.

METEORITES AND WHAT THEY TEACH US.

II.

By H. Hensoldt, Ph. D.

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Fortunately it is an easy matter to distinguish meteoric iron from iron which has been artificially produced, no matter when or by whom. If we file or grind a piece of meteoric iron so as to produce a smooth, or better still, a polished surface and apply to this surface a few drops of diluted hydrocloric, sulphuric or nitric acid,we shall see it covered,as if by magic, with extraordinary parallel lines, rods or bars, intersected by others under certain definite angles. They are exhibited almost invariably by the iron of meteorites and are known as Widmanstättian lines from their first discoverer. They are due to a crystalline structure of the iron and to the fact of its being nearly always alloyed with a small quantity of nickel (also a trace of cobalt and copper). Crystallization, as pointed out by Dr. Huntington,[1] in some respects may be looked upon as a purifying process. When a mineral crystallizes it invariably endeavors to rid itself of foreign particles, which are generally present, by driving them to the periphery where they form a zone or layer. If the crystallization is then interrupted and resumed again at a later period the expelled matter will form a zone in the crystal, often of extreme regularity and this process may be repeated a dozen times, so that in the sections of many crystals we find a series of zones of such foreign particles, each representing the outline of the crystal at a certain period of its development.

Now during the solidification of the meteoric iron there was an effort as it were on the part of the pure iron to rid itself of the nickel by driving it in successive layers to the margin; thus we have in the meteoric irons bars of almost pure iron, the so-called Balkeneisen or kamacite alternating with narrow seams of iron rich in nickel, the taenite or bandeisen.

The Widmanstättian lines were already discovered in 1808 and as early as 1816 Sömmering recorded his opinion, as the result of careful angle-measurements, that they were due to an

[1] "On the crystalline structure of iron meteorites" Proc. Am. Ac. Cambridge, 1886, p. 491.

octahedral crystallization. Now in 1848 another set of lines was discovered in certain meteoric irons by Neumann, especially in the iron which fell at Braunau in Bohemia in 1847. These lines, which are quite different from those above described, were found to denote a cubical crystallization and they have since been known as Neumann lines. They intersect each other at right angles, parallel to the faces of a cube and sometimes are traversed by diagonal lines, indicating a twinning of the cube.

The Widmanstättian and Neumann lines have hitherto served as a basis for dividing the iron-meteorites into octahedral and cubic irons. Dr. Oliver W. Huntington however has successfully shown that such a classification is neither natural nor fundamental and that the Widmanstättian figures and Neumann lines are sections of planes of crystalline growth parallel to the three fundamental forms of the isometric system, namely the octahedron, the cube and the dodecahedron.

Analysis has revealed that the cubic irons are purer (less alloyed with nickel, etc.) than the octahedral ones and Tschermak especially draws attention to the fact that in the case of artificial irons the pure iron tends towards a cubic crystallization with markings like the Braunau meteorite. This can be strikingly observed in the so-called spiegeleisen, a variety of cast-iron.

The element of time is of primary importance in determining the crystalline structure of the iron, as during a very slow process there would be a more complete elimination of foreign materials than during a rapid solidification. The action of the process of crystallization in eliminating impurities produces effects with many minerals not unlike those of the Widmanstättian figures, as we may see in rock-sections containing leucite, nosean, nepheline, etc.[2] That excellent observer Dr. Huntington also draws attention to the mica from Chandler's Hollow, Delaware, in which particles of magnetic oxide of iron are deposited in lines, which are also sections of planes of crystalline growth. Plates of this mica present, in the configuration of their lines, a close analogy to the etched surfaces of octahedral meteoric irons.

Prof. Sorby, in an article published in "Nature" in 1877 (vol.

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[2]Vide O. W. Huntington "On the crystalline structure of iron meteorites."

xv. p. 498) writes: "These facts clearly indicate that the Widmanstätt's figuring is the result of such a complete separation of the constituents, and perfect crystallization, as can only occur when the process takes place slowly and gradually. They appear to me to show that meteoric iron was kept for a long time at a heat just below the point of fusion, and that we should be by no means justified in concluding that it was not previously melted. Similar principles are applicable in the case of the iron masses found in Disco; and it by no means follows that they are meteoric, because they show the Widmanstätt's figuring."

Now these Greenland iron masses were discovered by Nordenskjöld in August 1870. It had been known for a long time that the Esquimaux were in possession of knives and hatchets which they had themselves made from iron, which seemed to be meteoric, as it exhibited the Widmanstättian lines. These implements were found in such abundance among the inhabitants of the southwestern coast of Greenland as to induce the belief that their supply of the raw material must be very considerable, but nothing could induce the natives to reveal the locality. In 1870 Nordenskjöld succeeded in clearing up the mystery and from information which he obtained at Upernavik he procured guides and proceeded to the island of Disco, a little to the south, under Lat. 69° 19′, where he found what he believed to be the largest meteorite ever discovered. It was an iron-mass about six feet long and nearly as broad, weighing no less than 42,000 pounds. Within a few yards from it lay another, weighing 16,000 pounds, and four or five more of lesser weight, but the entire sea-shore was also strewn with iron pebbles, varying from the size of a sand-grain to that of a cocoa-nut. Most of the larger masses presented the usual features of meteoric irons, in their outward appearance as well as their chemical constitution, for it was found that they consisted of iron alloyed with nickel and cobalt. Small wonder therefore that Nordenskjöld and even Tschermak for a long time persistently adhered to the opinion that they were of cosmic origin. But a careful examination of the locality by Steenstrup, who visited Disco in the Spring of the following year (1871), revealed the startling fact that these irons are, without exception, terrestrial, and have been weathered out of

a huge bed of basalt, which contains metallic iron in abundance.

Steenstrup found that at Disco, within a few hundred yards from the shore, the cliffs rise to a hight of 2,000 feet above the sea level. A basalt-breccia of dark-green color, and about 200 feet in thickness, rests on an ancient fundamental Gneiss. Above the breccia lies a bed of vesicular basalt wacke, the cavities containing cabasite, mesotype, analcime and other zeolites and this again is covered by a basalt-sheet of enormous thickness, sometimes attaining one thousand feet, composed mainly of anorthite, augite and *native iron*, the latter often in nodules of considerable size. This immense basalt stratum, produced by volcanic outbursts on the grandest scale during the miocene period can be followed along the entire western coast of Greenland, extending far beyond Smith's sound, over ten degrees of latitude, until it finally disappears under a huge glacier. We shall probably never know *how* far this gigantic lava stream, with its incalculable wealth of nickeliferous iron, stretches to the frozen North.

About ten years ago the writer, when examining a number of thin sections prepared from the meteorite of Braunfels, which was found in Germany in 1878, made a discovery which, however, he did not follow up in its important bearings, on the origin of these cosmical bodies, as the meteoric character of the Braunfels specimen was not clearly established. Tschermak and Brezina, for instance, declared the meteorite of Braunfels to be a pseudo-meteorite, on the ground that it differed so much in its structural features from every other known meteorite, as to render its extra-terrestrial origin very doubtful. But quite recently the writer has made the same discovery in the meteorite of Loutalaks, a well authenticated meteorite, which fell in Finnland in 1813 and also in that of Nobleborough, Lincoln county, Maine, as well as in that of Bustee, which fell in India in 1852. These meteorites are of a brecciated character and belong to a class which has been called howardites by Gustav Rose. They consist of angular fragments of anorthite, pyroxene, etc. with little or no metallic iron.

Now the writer's discovery, does not, like that of Dr. Otto Hahn, relate to organic remains; if it did it is doubtful whether he would have the courage to communicate it to the

world after Hahn's ludicrous fiasco. He has simply discovered fluid enclosures in the sections of at least three meteorites, minute cavities, filled with a liquid such as we find in abundance in terrestrial rocks. This may seem a very trifling matter, but we shall soon see that its significance is very great.

There is nothing more common in terrestrial minerals than little enclosures of fluid. If we prepare a thin section from one of the whitish quartz-pebbles to be found in every river-bed or gravel deposit and examine it under the microscope with a low magnification, we observe the whole field crowded with minute dust-like particles like a sort of cloud. Now if we increase the magnification these dots will enlarge in proportion to the power employed till each expands into a well-defined cell or cavity, in the interior of which a round object is seen constantly moving about. These cell-like objects are cavities filled with a liquid and the moving body in each is a bubble which is perpetually altering its position. In the largest of the cavities the motion is barely perceptible, but in the smaller ones it is quite lively, the bubbles darting rapidly from one side of the cell wall to the other. Now what causes the white appearance of the so-called milky quartz? Some coloring-principle, one would naturally conclude. Nothing of the kind; the white color is entirely owing to the presence of countless millions of fluid enclosures. The cavities do not imprison a white liquid; the white color is merely an optical phenomenon due to the reflection of the light, by the myriad walls of the cavities. We have exactly the same thing in snow, which is not white by virtue of a color; if we melt it we get the clear water of which it is composed.

Before we return to our meteorites a few observations on the cause of this perpetual motion may not be out of place. This bubble-movement has nothing to do with "Brownian" motion. In the latter we have minute solid particles driven about by molecular currents in a liquid. If, for instance, we dissolve a little Indian ink or gamboge in water and examine a drop of this under a "quarter" or "sixth" objective, we are startled to behold a very lively motion of the minute particles, a motion which never ceases till the drop has evaporated, and if we were to enclose it in an air-tight cell it would continue for years, or centuries for that matter. This is Brown-

ian motion. But the bubble-movement in our fluid cavities is due to the ever-varying temperature of the atmosphere. The temperature of the air which surrounds us is never constant, although we can not with our coarse instruments perceive very small differences. We only see the rise and fall of our thermometers after changes more or less considerable, but in reality there is a perpetual change of level in the quicksilver column. If we were to focus a high-power objective on the marginal level of that column we should see it constantly shifting and never observe it at rest. The same effect can be shown with a delicate spirit-level. If a spirit-level be placed on a table and so adjusted that the bubble is in the center, the holding of one's hand in the air within a foot's distance from the end of the tube suffices to cause a disturbance. The warmth of the hand drives the bubble slowly from its position which it will resume when the equilibrium is restored.

The liquid imprisoned in the cavities of quartz and other minerals is generally water. Sometimes this water is strongly charged with chloride of sodium and in the cavities of many granites (notably in those of Cornwall) we frequently observe cubic salt-crystals floating about in the liquid. This would indicate a saturated solution which once doubtless filled the entire cavity, but in the course of ages some of the water either evaporated through the rock or a considerable lowering of temperature took place so that a corresponding quantity of the salt was precipitated. Occasionally the liquids are hydrocarbons, oily, petroleum-like substances.

About twenty years ago Vogelsang and Geissler made the singular discovery that in many rocks the imprisoned fluid consists of carbon dioxide, liquified carbonic acid, and from experiments which the writer has made, he has come to the conclusion that the fluid contained in the cavities of the meteorites of Loutolaks, Noblesborough and Bustee is likewise CO_2. On warming the meteoric sections by means of a wire coiled around the slide and observing the temperature on a stage-thermometer, the writer invariably found that the bubbles suddenly vanished when a temperature of about 30° C. was reached, but returned again in cooling without any apparent diminution in size or moving-capacity. Now between 30° and 31° C. lies the so-called "critical point" of carbonic acid, that is, above

this temperature carbonic acid can not exist in its liquid condition, however great the pressure may be to which it is exposed. This is in accordance with an interesting law the existence of which has been proved beyond any doubt by recent investigation. After certain temperatures are reached liquids enter into the gaseous state, no matter what the pressure may be. The temperature under which a certain liquid is no longer able to retain its characteristic features, but transforms itself into a gas, has been called by Prof. Andrews, of Belfast, its "critical point" and from experiments made by him it has been convincingly shown that it is not possible to maintain the liquid condition of CO_2 at any temperature beyond 30° 92′ C. In all the cavities contained in these meteoric sections which have come under the writer's observation the bubbles suddenly vanished at a temperature of from 30° to 31° C., sometimes even exhibiting that peculiar phenomenon of ebullition to which Mr. Noel Hartley, more than ten years ago, already drew attention. Now if the enclosed fluids had been water the bubbles would not have shown the least indication of a change at this temperature. The writer heated a section of quartz, the cavities in which he knew to contain water, to the boiling point without detecting the smallest effect on the bubbles.

Among the many chemical tests which have been resorted to in order to determine the presence of carbonic acid in mineral cavities we will only mention that of Vogelsang and Geissler, of Bonn, who crushed rock-crystals in which cavities occurred which they suspected to contain liquified CO_2. under baryta water, and observed that the latter became turbid, owing to the formation of carbonate of baryta.

Now, taking for granted that the fluid material contained in the cavities of these meteorites, is really carbonic acid, which we may safely do, as it presents no points of analogy to any other known substance, and that the bubbles, which move so restlessly about in their tiny prisons are the same substance in its gaseous condition; what do these facts teach us respecting the circumstances under which the meteoric masses were originally formed?

Carbonic acid is a gas which can only be reduced to the condition of a liquid by extreme pressure. It requires a pressure of no less than 65 atmospheres to condense CO_2, which is

equivalent to a column of water 2,000 feet high or a rock-stratum of about 700 feet·thickness. Wherever we find enclosures of liquid carbon dioxide in terrestrial rocks—and we find them frequently—we may take it for granted that the formation of those rocks took place deep in the earth's crust under the gigantic weight of superincumbent masses. Cavities, containing CO_2 often occur in basalts and other so-called "basic" lavas, which are known to be derived from deep-seated reservoirs beneath volcanoes, where besides the weight of tremendous rock-masses above we have the compressing force of great quantities of elastic vapor held in confinement, while in the so-called acid lavas(lavas rich in silica)of which there is very conclusive evidence that they are formed at no such very great depths, the presence of liquified CO_2 is extremely rare. The fact that these cavities are often contained in the quartz of granites may be regarded as a most important evidence that the granites have been formed deep in the earth's crust, under conditions of enormous pressure and we never find this liquid in sedimentary strata or any other materials which are unlikely to have been exposed to extreme pressure during their formation.

But how about *extra-terrestrial* rock-masses? How about meteorites in which we find liquified carbonic acid in millions of minutes cavities? Could they have originated under circumstances totally different from those which prevail on this globe? Could the CO_2 in them have been condensed to a liquid *without* extreme pressure? Certainly not; this would be little short of a miracle and as we cannot conceive the possibility of such a great pressure in a meteorite, weighing only a few pounds, we are driven to the conclusion that those bodies at one time of their history, existed in the interior of mightier masses, planets perhaps, of which they are the fragments.

It has,as we know,been ascertained by the means of the specroscope that the fixed stars are for the greatest part composed of elements identical with those which prevail on this globe and that most of the planets that are within our observation are composed of materials very similar to those which constitute the earth we have strong grounds for believing. Then we know that the sun's temperature is so enormous that all the non-metallic elements and many of the metallics are in a condition of vapor and the rest of the metals in a state of fiery

liquid, and that probably all the fixed stars are similar masses in different stages of cooling. We furthermore find traces of mighty igneous action on those planets which are nearest to our observation, for instance the moon, which is covered in many parts of its surface with volcanoes on the grandest scale (now, as it seems, extinct for ever) and our own earth yet displays mighty volcanic forces which seem to have been grander still in the past.

What, therefore, can there be improbable in the supposition that among the myriads of those fiery drops or half cooled orbs, but in whose interiors mighty volcanic elements still are busy, one should *explode* now and then and people the universe with its fragments. We have evidence to prove that in past periods of the earth's history the explosive force of vapors held in confinement has been great enough to blow away mountains ten miles in diameter, leaving chasms which are now, in many instances filled by lakes. On the island of Timor, for instance, an active volcano, which was visible from a distance of 300 miles at sea, was blown away during a terrific eruption, and the circular lakes of Italy, Auvergne, the Eifel, etc., mark the sites of ancient volcanoes. The remarkable ring-mounds which we observe on the moon have in the writer's opinion, originated in the same manner and tell a tale of explosions so stupendous and terrible that the mind can barely conceive it. What eruptive forces have been able to achieve on this globe even a few years ago is shown by the occurrences on the island of Java and during the still greater eruption of Papandayang in 1772 more than half the mountain was blown away, it was in one single night reduced in height from 9000 to 5000 feet.

That heavenly bodies, such as planets, should be capable of exploding seems not only possible but extremely probable. If in the interior of our own planet the force of vapors held in confinement has been great enough to transplant gigantic mountains and to effect the most appalling changes in the aspect of the surface, there is nothing illogical in the conclusion that vast accumulations of gases may lead to the scattering of whole worlds or that the violence of explosion may ruin them partly, hurling fragments far enough to place them beyond the attraction of the remaining wrecks. On such stupendous explosions taking place it is almost certain that great

numbers of fragments would be sent through space in similar directions, forming swarms which, on coming within the attraction of some great body, would take definite courses, while many others would be so directed as to diverge the further they move, till each pursues a solitary path. The magnificent showers of so-called shooting-stars, have been proved to be caused by the passage of the earth through such bands of travelling bodies, and even comets have now been identified with streams of planetary bodies of minute size, moving in regular orbits through our system.

Now as it is extremely probable that many meteorites are fragments of the celestial bodies vastly mightier than themselves, their closer examination leads us to the conclusion that at least *some* are derived from planets very similar to, if not identical in composition with our globe, and that they come from the *interiors* of those masses and are the resultants of explosion. If we examine those minerals which most frequently occur in meteorites, we are startled to observe that they are almost without exception those which constitute the basic lavas, viz.: those volcanic rocks which, as we have already pointed out, are derived from the deepest seated igneous reservoirs in the crusts of our planets. Olivine, enstatite, augite, anorthite, magnetite and chromite are most frequently contained in meteorites and these are the very minerals of which the basic and ultra-basic lavas almost exclusively consist. Masses bearing the most striking resemblance to meteorites are sometimes ejected from volcanic vents in the shape of so-called volcanic bombs and even metallic iron has now been discovered in the most basic of all known terrestrial lavas, viz: the Ovifak basalt, iron alloyed even with two other metals, nickel and cobalt, which form so characteristic a feature in the iron of meteoric origin.

We know comparatively little of the interior of our planet, being only acquainted with a very insignificant portion of its crust and even the basic lavas, which in all probability represent the deepest known regions of that crust, furnish us with but very scanty information respecting the nature of the vastnesses beneath. But though we shall probably never be able to ascertain the condition of the interior of the earth by direct observation we are in the position to say that the masses forming the bulk of this interior must be quite differ-

ent from those which constitute the crust. It has been established that the average density of the earth is a little over $5\frac{1}{2}$; in other words the earth weighs $5\frac{1}{2}$ times as much as a globe of the same size composed of water, but that the specific gravity of the known crust, viz., the average weight of the rocks, minerals, etc., with which we are acquainted is less than $2\frac{1}{2}$. We are thus driven to the conclusion that the interior of the globe is composed of substances having more than twice the density of those which we find at the surface.

Now it seems to the writer that in the meteorites which have from time to time fallen upon the earth's *surface* we have been provided with a most important collection of objects on which to study the character of its interior. Being the fragments of other planets they confirm in a remarkable manner those general conclusions which we have been enabled to draw from undisputed facts respecting the interior of the globe. The density of by far the greatest number of them wonderfully coincides with that of the greater portion of the globe. It has often been pointed out that the interior of the earth is in all probability a vast metallic mass consisting mainly of iron, and among the meteorites we have a great preponderance of iron-masses, while the different classes of meteoric, with exception of the chondrites (which beyond doubt have resulted from the accumulation of cosmic particles) represent a variety of lesser depths, those which are of an essentially stony character being delivered from portions of the crust.

It has been the writer's endeavor in the above to give a brief outline of what has been accomplished in recent years by those devoted to the study of meteorites. Much of what he has stated will be nothing new to those who may be acquainted with the existing literature on meteorites and who have kept pace with the progress of recent inquiry. But it would gratify him if his efforts have awakened more than a passing interest in others, if he should have succeeded in showing that the study of meteorites has an importance far beyond that which they have hitherto attributed to it; that it is of importance alike to the physicist, astronomer and philosopher; that without it no rational conception of the constitution of this universe is possible and that even now no progressive geologist, mineralogist, chemist or teacher of natural history—in short

no one who pretends to a scientific education—can afford to ignore it.

NOTES ON THE ORE-DEPOSIT OF THE TREADWELL MINE, ALASKA.

By George M. Dawson, D. S., F. G. S.
Assistant Director Geological Survey of Canada. Read before the Royal Society of Canada, May 8th, 1889.

The Treadwell mine, situated on Douglas island, Alaska, is a somewhat remarkable ore-deposit, and has of late years become prominent as a producer of gold. I am not aware that any systematic description of the character of this deposit has yet been published, and this circumstance may render the following notes on its mode of occurrence of interest, while the microscopical examination of the gold-producing rock by Mr. F. D. Adams, throws further light on the character of the deposit. My examination of the mine itself was made, by the kind permission of Mr. Treadwell, while I was on my way back from the Yukon District in the autumn of 1887.

Attention was first drawn to this deposit, by the discovery of gold-placers, which were worked for several years previous to the finding of the ore, and in a few cases were found to pay well. The gold of the placers was fine, but rough and unworn in character. The placers occurred on the surface of the ore-mass itself and on the rather steep slopes running down from its outcrop to the shore, and must have been produced by the natural decay of the ore subsequent to the glacial period, as they were found to lie above the boulder-clay, which fills many of the hollows and rests directly on the rock wherever it occurs. It may be noted here in passing, that Mr. Treadwell informed me that barnacles and various marine shells had been found still adhering to the surface of the rock, in places from which the clay had been excavated, up to a hight of 150 feet above the present sea-level.

The ore-mass, which has been extensively exposed by stripping and proved as well by several drifts, has a thickness of about 400 feet. Its length, or at least the length of that part of it which will pay for working, is not accurately ascertained but must be considerable. It runs in a general northwesterly direction,parallel to the shore of the eastern side of Douglas island and is bounded to the northeast and southwest by dark, rather slaty argillites, which, from analogy with similar rocks which

I have examined on the coast of British Columbia, to the southward, may very probably be of Triassic age and referable to the Vancouver series of the reports of the geological survey of Canada.[1] On the northeast side, in the immediate vicinity of the Treadwell mine, the ore-mass is bounded by a zone about seventy feet in thickness of greenish schistose slate, but it is uncertain whether this zone owes its character to peculiar alteration, or to a difference in original composition, as the slaty rocks as a whole, do not show any marked degree of alteration in the vicinity of the ore. A slate 'horse,' more or less completely silicified, is passed through in one place in the main working drift, but its character as a portion of the country rock is still clearly apparent. The argillites or slaty rocks are often found to be flexed and tilted at high angles along this part of the coast, and it is probable that the main period of elevation of the coast ranges has been subsequent to that of their deposition.

The ore itself presents none of the characters of that of an ordinary lode or vein, being without any parallel banding or arrangement of its constituent minerals, and showing no such coarse crystalline structure as a lode of larger dimensions might be expected to exhibit. It is, on the contrary, a nearly homogeneous crystalline mass, of medium grain, and pale grey in color, evidently consisting principally of quartz and white feldspar with a little calcite, and specked throughout with small cubical crystals of iron pyrites. The quartz, however, as well as the calcite and pyrites, may occasionally be found traversing the mass in small irregular veinlets and stringers, and the pyrites in some instances forms little distinct aggregations or bunches.

A clue to the true nature and origin of this deposit, (otherwise of a somewhat enigmatical character) appears to be afforded by the existence in it, in some places, of kernels of a distinctly granitoid appearance. Some of these were observed to be six inches in diameter, and portions of others were found which may have had a diameter of several feet. The material of these kernels—which around their edges blend imperceptibly with the main mass,—is similar in size of grain to that of the ore-mass itself, but includes little or no pyrites. It is harder and less evidently decomposed, often greenish in tint from the

[1]See Annual Report Geo. Sur., Can., 1886. p. 10 B.

development in it of chloritic minerals or reddish, and, microscopically examined, shows two feldspars with some quartz. In general aspect it in fact resembles the varieties of fine grained granite which are frequently met with near the junction of an ordinary granite with other older rocks through which it has broken.

The impression formed from such examination of this remarkable deposit as I was able to make is, in fact, that it represents the upper portion, or "feather edge" of a granitic intrusion, probably contemporaneous and connected with the characteristic granites of the neighboring Coast Ranges, but which, owing to peculiar conditions, has become decomposed and silicified by solfataric or hydrothermal action, to which the concentration of gold in it and the deposition of pyrites, are also due. To what extent the presence of gold may depend on the occurrence of the adjacent slaty argillites (elsewhere known to contain auriferous quartz-veins) it is impossible to say, but it appears not improbable that the deeper portions of these rocks may, under the action of such heated solvent waters, have afforded both the gold and the pyrites. It is conceivable that the hydrothermal action which has affected this part of the original granitic magma may have been due to the water included by the mass itself while in a state of "aqueo-igneous" or "granitic" fusion, the escape of such water through the substance of the upper part of the intrusive mass being rendered possible by the relief from pressure consequent on the approach of the intrusion to the actual surface. It may, however, perhaps with greater probability, be supposed that the water included in the adjacent sedimentary deposits, became vaporized by the heat of the intrusive mass, and found its way to the surface in the form of steam through the substance of that mass. It will be noticed that Mr. Adams finds evidence in the microscopical character of the rock of much crushing and fracture, so that in any case it must have afforded a convenient channel for the passage of heated waters or steam, and this appears to have been one of the more important circumstances leading to its mineralization.

The slaty rocks themselves in the vicinity of the ore-deposit are traversed by numerous small veins of quartz; and at the distance of a few miles (on the mainland opposite Douglas island in "Silver Bow Basin") similar slaty rocks are found

to be cut by quartz-veins of greater width, which hold visible gold. The association of metalliferous quartz-veins with masses of granite or other intrusive rocks traversing sedimentary deposits is a fact of general observation. Had the higher portions of the rocks, which may at one time have completely covered this particular granitoid intrusion, remained, it might be anticipated that it would be found to pass upward into one or more ordinary auriferous quartz-veins, these filling fissures through which the heated waters ultimately reached the then surface. In depth the present ore-mass should be found, on the other hand, to pass gradually into ordinary unaltered granite. Many cases of course occur in which intrusive masses have led to the formation of metalliferous veins without producing extensive low-grade metalliferous deposits of an intermediate character, such as the one here naturally exposed by subsequent processes of denudation appears to be. This deposit therefore affords an interesting example of the manner in which intrusive masses may directly give rise to ordinary metalliferous veins.

The quantity of gold contained in the ore of the Treadwell mine is small. Though not informed as to the actual yield, I believe it to be on the average less than $10 to the ton. The ore is, however, easily and cheaply obtained by work resembling quarrying rather than mining, and can in consequence be profitably worked on a large scale. It is not intended here to enter into particulars as to the mode of working, but it may be stated that at the time of my visit 120 stamps were constantly employed, and that since that date this has been increased to 240, the quantity of ore milled daily being now reported at from 500 to 600 tons. A considerable proportion of the gold is "free" and this is saved on amalgamated plates. The remainder is contained in the iron pyrites, which is separated by Frue Vanners. The pyrites was then formerly roasted in revolving cylinders, but these were being replaced at the time of my visit by continuous automatic furnaces similar to those employed in sulphuric acid works. The gold is dissolved from the roasted product by chlorine gas, and precipitated by sulphate of iron.

As the geological conditions are very similar along the west coast all the way from Lynn canal to the strait of Fuca, it appears highly probable that other deposits of a similar char-

acter to that here described remain to be discovered. With the facts developed in connection with this mine in view it would appear to be well worth while to subject to examination and assay all pyritous granitoid rocks in contact with or penetrating the sedimentary formations, and in particular those which may be found to traverse the slaty argillites of the formation above referred to as the Vancouver series.

ON THE MICROSCOPICAL CHARACTER OF THE ORE OF THE TREADWELL MINE, ALASKA.

BY FRANK D. ADAMS, OF THE GEOLOGICAL SURVEY OF CANADA.

(Read before the Royal Society of Canada, May 8th, 1889.)

The material employed in this examination consisted of several small specimens kindly placed at my disposal by Dr. Geo. M. Dawson who collected them at the Treadwell mine in 1887, together with two collected by Mr. R. G. McConnell, of this survey, who visited the mine when returning from the Yukon country last autumn.

The ore is a more or less altered granite, rather coarse in grain and of a light grey color. As mentioned by Dr. Dawson in the previous paper it encloses "kernels" often greenish in color and distinctly granitoid in appearance, having a diameter of from six inches to several feet. These are of the same grain as the rest of the mass, but are harder and less evidently decomposed, and pass rather sharply but imperceptibly into the ordinary grey granite. As these represent the granite in its least altered form they will be described first.

The Kernels.—One of the hand specimens shows a portion of one of these "*kernels*" which is seen to differ from the ordinary granite in two particulars: 1st, in being light reddish in color instead of grey; 2d, in being free from quartz-veins and holding but little pyrite. When a thin section is held against a dark background it is seen to be made up of numerous rather large translucent crystals or individuals closely packed together, but separated by narrow, transparent, intermediate lines. Under the microscope these translucent crystals are seen to be feldspar a good deal decomposed (which accounts for the opacity) while the intervening spaces are found to be in part grains of quartz or of broken feldspar and in part the edges of feldspar crystals, which are often much freer from decomposition products than their central portions.

Most of the feldspar is untwinned and is referred to orthoclase. A much smaller amount, however, shows polysynthetic twinning, in a few cases two sets crossing at right angles, and is therefore plagioclase. In one of the sections a few large grains showing perthitic intergrowths were seen. Both feldspars often possess a marked zonal structure, caused or accentuated by the accumulation of decomposition products along certain concentric lines. Although many of the feldspar individuals extinguish simultaneously over their whole extent many

others show the peculiar mottled extinction produced by pressure, while others again are distinctly seen to be in the act of breaking up into a mass of small grains. Both feldspars also, although having more or less perfect crystalline forms, are almost invariably broken into little grains around their edges which gives them a somewhat rounded contour, the edges being often highly serrated. In addition to these feldspars the rock contains quartz, hornblende, epidote, ilmenite, sphene (?), apatite, hematite, calcite, chlorite and pyrite.

The quartz is present in rather small amount and lies chiefly in corners or between the large feldspar individuals. It is uniaxial and positive and shows an uneven extinction. Judging from its mode of occurrence it is in great part at least a primary constituent of the rock. The hornblende occurs only in very small amount and is not seen in all sections. It is pleochroic in light green and light yellowish green tints and is without good crystalline form, being somewhat fibrous in character, the extinction making an angle with the cleavage, for which the highest value observed was 17°. The epidote is present in small quantity, in irregularly shaped grains, or aggregates of grains, often associated with the hornblende. It shows the characteristic pleochroism and is probably secondary in every case. Primary epidote does however occur in a similar, but unaltered mass of biotite granite, which is erupted through rocks of the same series as those cut by this granite on Wrangell island, Alaska. (See appendix 5 B, Annual Report of the Geological Survey of Canada, 1887). A small amount of ilmenite or titaniferous iron ore is also found in the sections. It is opaque and black, sometimes having a slight reddish tinge by reflected light. In one case a few small grains were seen imbedded in broken feldspar. Each grain had been broken into several pieces which lay close to one another and were cemented together by a greyish material resembling leucoxene, which is frequently observed associated with the iron ore in this rock. A few little flecks of hematite are seen as inclusions in the feldspar. The sphene and apatite are present in small amount, the latter being in rather short and stout crystals.

In addition to these minerals the rock contains remains of some mineral now replaced by aggregates of decomposition products which frequently present rather perfect oblong outlines as if the original mineral had possessed a pretty good crystalline form. The principal constituent in these aggregates is calcite, which occurs in grains having the peculiar silvery white color usually exhibited by this mineral between crossed Nicols. Associated with it is chlorite, epidote, and often very small amounts of quartz, pyrite, and ilmenite or magnetite. In one of these masses a grain of light green somewhat fibrous hornblende was found filled with calcite grains and associated with epidote, chlorite and hematite. The mass appears originally to have been all hornblende, of which these other minerals are decomposition products, in fact all these aggregates probably represent original hornblende grains, chlorite, quartz, calcite and epidote being the minerals into which the hornblende of granites usually splits up in decomposing.

The examination of the "kernels" therefore shows that they are composed of a considerably crushed and altered granite, probably belonging to the class of hornblende granites.

The Ordinary Granite—The grey granite which constitutes the mass of the rock and encloses the *kernels*, in the hand specimen shows no perceptible foliation and is impregnated with pyrite and quartz, the latter occurring also in the form of little veins traversing the rock in various directions. The quantity of these minerals present however varies considerably in the different specimens. When examined under the microscope the rock is found to be composed of orthoclase, plagioclase, quartz, calcite, pyrite, with in some cases a very small amount of titaniferous iron ore and of some zeolite. Hornblende, chlorite, epidote and the other accessory minerals above mentioned were not found in any of the sections.

As in the case of the "kernels" the rock exhibits a very distinct cataclastic structure, induced apparently by crushing, but the crushing has gone much further in some cases than in others. Both feldspars are more or less decomposed and show mechanical deformation, the twin lines of the plagioclase being often bent and the crystals fractured and faulted transversely, and often presenting an appearance of having been shoved into one another. The individuals of both feldspars are usually surrounded by borders of broken grains from which arms of similar broken material frequently extend into the unbroken grains. In many other cases when the feldspars are examined between crossed Nicols they can be seen to be in the act of falling apart into a number of grains similar to those constituting the above mentioned borders. The orthoclase is present in larger amount than the plagioclase but as in the case of the "*kernels*" the latter mineral is as a general rule rather better crystallized than the former.

Whether any of the quartz was an original constituent is a question which it is impossible to determine. A large amount of this mineral however is always present and most of it is of secondary origin, occurring in the rock in veins or in irregularly shaped masses. Small veins are found in all the specimens and are often seen sending off lateral arms into the rock. The quartz is clear and colorless and often contains lines of minute cavities. It is usually in large individuals, which although occasionally, especially in the narrow portions of the veins, show an uneven extinction, generally extinguish simultaneously over their whole extent. A considerable length of the vein is often composed of a single individual. The edges of the veins against the rock are well defined and the component grains come together along sharp lines without any of the interstitial broken material. Calcite often occurs associated with the quartz sometimes filling a portion of the same vein. In some cases it even preponderates over the quartz, forming the principal constituent of the vein. The quartz with its associated calcite is also seen in some sections in irregularly shaped masses, which, though pretty sharply defined against the more or less decomposed rock, at other times occur so that it is impos-

sible to determine their exact limits owing to an impregnation of the rock about their edges, with the minerals of the vein. In these veins and masses both minerals occur in large grains. Very irregular-shaped masses of the calcite, also clearly secondary and often associated with pyrite are also found, especially in the crushed and broken portions of the rock. As before it occurs in large grains, frequently enclosing little bunches of a black, rod-like mineral. Little isolated crystals of calcite also occur in a similar manner. The calcite does not occupy cavities into which the other minerals have crystallized but seems to have eaten its way into the feldspar, in some cases showing crystalline boundaries in the substance of the latter. Pyrite is present in considerable amount and is generally found well crystallized in little cubes. It occurs almost invariably in the crushed and broken portions of the rock and is very frequently associated with the calcite. In one slide, reproduced in Figure I, a mass of pyrite was observed enclosing a fragment of orthoclase, evidently a corner broken off from a large individual adjacent to it *and with which its orientation was identical.* In the figure the clear spaces show unbroken fragments of orthoclase separated by broken material, the result of crushing. A number of these small grains near the top of the cut, which are bounded by a somewhat heavier line, show one of the large fragments in the act of falling to pieces, a phenomenon which can be observed in most of the slides, when they are revolved between crossed Nicols. A number of little cubes of pyrite are seen in the broken portion. After the corner of the large orthoclase individual had been broken off, the pyrite was evidently deposited in the crack and around the detached fragment. The other little white spaces in the same pyrite mass represent little inclosures of quartz. These facts together with the occurrence of the pyrite almost exclusively in the crushed portions of the rock clearly prove the secondary character of this mineral.

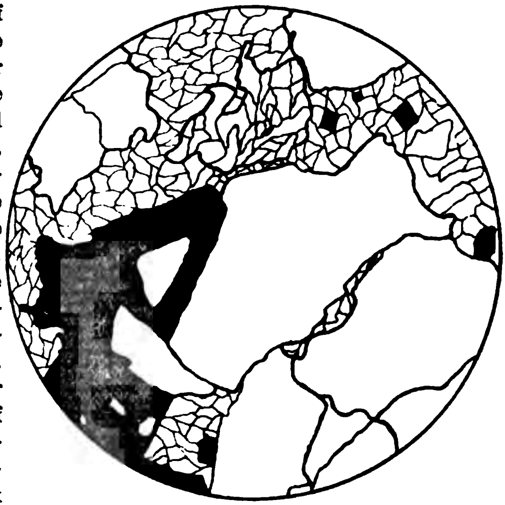
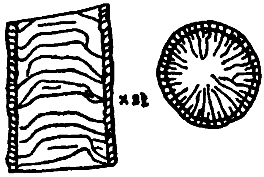


FIGURE I.
Section of the granite showing cataclastic structure with deposition of secondary pyrite. Magnified 32 diameters.

As it was a point of much interest to ascertain if possible the manner in which the gold occurred in the rock, the sections, twelve in number, representing five hand specimens very carefully examined

and at distances varying from one to three millimeters, more prominent single ridges give character to the external stem. By means of a pocket magnifier a third set of very delicate, closely approximated wrinkles may be distinctly seen.

Adult corallites average five or six millimeters in diameter, are somewhat loosely and irregularly set, usually less than a diameter apart and occasionally coalescing for a short distance. The nature of the calyx is unknown. The number of septa is quite regularly 44; alternately longer and shorter. The longer are somewhat flexuous, as seen in cross section, and extend about two-thirds of the distance from the outer wall to the center, rarely reaching it. The shorter septa extend about one-fourth of this distance and are intersected near their centers by a thin but very distinct inner wall, at a distance of from .5 to .75 of a millimeter from the outer. This second wall is as thick and as well defined as the outer, and is separated from it by a single row of vesicles, shown in the longitudinal section; these vesicles averaging .4 of a millimeter in hight. This arrangement, of course, gives no trace of dissepiments in cross section except where double vesicles intervene seemingly by accident.



The inner area is occupied by a series of laterally depressed tabulæ; about fifteen in the space of ten millimeters, terminating at the inner wall. These are somewhat irregular, but nearly horizontal and flat at the center; sometimes uniting with each other before reaching the inner wall. In regard to the nature of this second wall there can be no doubt it exists in all the stems, distinctly defined; a *continuous* partition separating the vesicular from the tabular area.

In growth, size and in the number of septa this specimen is identical with *Eridophyllum simcoënse* Billings, or what Dr. Rominger prefers to call *Diphyphyllum simcoënse.* In the original description of this species Billings makes no mention of a second wall, and Rominger asserts that none exists. However, in specimens identified by the latter as *simcoense* and now in the museum of the University of Michigan, identically the same structure is seen in the best preserved stems, and in others *traces* of the same inner wall frequently occur, even in the specimen the photograph of which is given in

plate XLVI, fig. 4, in his "Fossil Corals of Michigan." I am inclined to believe that this fossil is what was described by Billings as *Eridophyllum simcoënse* and that its excellent preservation discloses features not before ascribed to that species. This point can be settled if geologists will carefully examine their best preserved specimens.

Meek has described, from the Devonian of Nevada, in VOL. IV of the "U. S. Geol. Exploring Expedition of the Fortieth Parallel," page 29, a specimen to which this is very closely related and to which he gives the name *Diphyphyllum fasciculum*. This has a similarly placed inner wall, separated from the outer by a single row of vesicles, and corresponds in its growth, size and number of septa. It differs, however, in having the shorter septa thinner than the others, and in having them generally terminate at the inner wall. In the specimen here described no such difference in the thickness can be detected, and the shorter septa never so terminate, but extend into the tabular area. There would also seem to be a minor difference in the arrangement of the tabulæ.

Geological Laboratory University of Michigan, May 17, '89.

IRON BUTTE, MONTANA---SOME PRELIMINARY NOTES.

BY S. CALVIN.

Near Glendive, Montana, occur some excellent examples of that peculiar topographic sculpturing which is known as "bad lands." Bad lands they certainly are from any ordinary point of view, and they extend along on the south side of the Yellowstone river for a distance of twelve or fourteen miles. The width of the area measured at right angles to the direction of the river is not very great. Drainage valleys cutting through them nearly at right angles divide the bad lands into more or less perfectly defined masses, that, notwithstanding their sculptured ridges and pinnacles and V-shaped ravines, rise somewhat prominently above the river and the secondary valleys. These several masses are known as buttes, and each has its specific designation.

About ten miles up the Yellowstone westward from Glendive comes Iron Butte, separated from its neighboring buttes by the valley of Sand creek on the east and Cedar creek on the west. Iron Butte is about as high as either of its fantastically carved neighbors, but geologically it belongs to a much lower

horizon. Cross either valley, to the east or west, and you find the buttes carved in the sandstones and shales of the Tertiary, while Iron Butte is made up wholly of deposits belonging to the Ft. Pierre or Fox Hills group of the Cretaceous.

On the west side of Cedar creek the Tertiary strata dip at quite a high angle to the westward; to the east of Sand creek they are very nearly horizontal. A strong fold in the strata giving the sharp dip toward the west, with probably a slight fault along Sand creek valley would account for the interesting relations of the Cretaceous deposits exhibited at Iron Butte.

The fossils of Iron Butte are especially interesting on account of the fact that species elsewhere characteristic of the Ft. Pierre and Fox Hills groups respectively are here commingled in such a way as to indicate that both faunas lived together on amicable terms and were perfectly at home in the Cretaceous seas occupying that particular region. Professor Meek in his great work on "Invertebrate Paleontology," Gov't Printing office, 1876, refers frequently to a locality on the "Yellowstone river, one hundred and fifty miles from its mouth, where it (the species he is describing) occurs in beds containing a blending of the fossils of the Ft. Pierre and Fox Hills groups of the upper Missouri Cretaceous series." All the species thus described by Meek occur at Iron Butte, and as the distance by river is about one hundred and fifty miles from the mouth of the Yellowstone, there is reason to believe that Iron Butte is indeed the locality from which Meek's specimens were obtained. Geologists may be interested in having this somewhat remarkable exposure more definitely located than was possible at the time Meek wrote.

The fossils at Iron Butte are not distributed generally through the deposits, but occur in hard, irregularly shaped concretionary masses that break with a splintery fracture into sharp angular fragments. These concretions may be from a few inches to several feet in diameter. Sometimes they seem to be disposed in layers, but very frequently it is impossible to discover any order of arrangement.

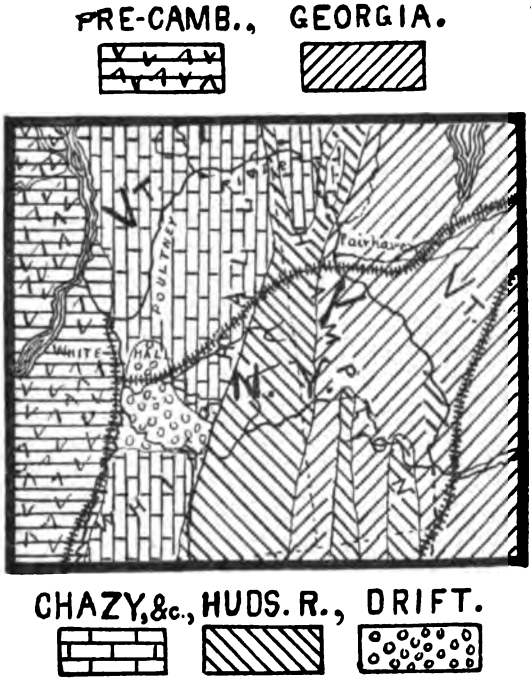
Two or more distinct assemblages of fossils occur at Iron Butte, but the matter needs further investigation. For example the *Scaphites nodosus* var. *plenus* and the *S. nodosus* var. *quadrangularis* do not occur together. Moreover each variety

has its own particular associates. Just what these associates are in every case and what the relative position of the *plenus* to the *quadrangularis* beds, could not be determined during the brief visit paid to the locality by the writer.

ON CERTAIN CAMPTONITE DIKES NEAR WHITEHALL, WASHINGTON COUNTY, N. Y.

By J. F. Kemp and V. F. Marsters.

Our attention has recently been directed to the occurrence of dikes of eruptive rock near the state line between New York and Vermont, and nearly due east of Whitehall, N. Y. Mr. Ira Sayles, of the United States Geological Survey, came upon them while in the field under the direction of Mr. C. D. Walcott, and the past summer brought them to our notice. The field work necessary to the preparation of this paper was done by Mr. Marsters, and the rocks were then worked up in the laboratory by both the writers. Special interest attaches to these dikes, for the reason that no mention has been made, so far as we know, of eruptive rocks in this vicinity, although they are known some fifty miles or more to the north.



On the accompanying map the dikes are represented by two lines intersecting each other like a capital Y, in the Georgia slates just southwest of the Poultney river. The general geology of the neighborhood, as

shown by C. D. Walcott[1], consists of Precambrian strata west of lake Champlain, then to the east a band of Hudson River slates, then the Trenton, Chazy, &c., limestones, and lastly the Georgia slates, which contain the dikes. These slaty rocks are considerably distorted and folded, and in comparatively short distances vary in dip from 20° to 35.° In the vicinity of the dikes they are decidedly calcareous, and for considerable distances on either side are very much broken and seamed with veins of calcite. As compared with the overlying band of roofing slates to the east, they are somewhat softer, and a lighter gray in color. One dike strikes N. 40° E. the other N. 80° E. They vary from 3 to 4 feet in width. Macroscopically they are dark gray in color, quite soft and possess a peculiar granular appearance. They are also peculiar in that they exhibit amygdaloidal cavities, a phenomenon not shown by any other dike rocks of our acquaintance. The amygdules are filled mainly with calcite and vary in size from $\frac{1}{8}$ inch to such minute masses as can only be seen by the aid of the microscope. Occasional well developed crystals of augite are seen scattered through the rock mass.

Microscopic examination proves these rocks to be made up of augite, hornblende, plagioclase and innumerable small masses of magnetite, portions of which show complete crystallographic forms.

The augite occurs in well formed porphyritic crystals of pink and green colors showing prismatic cleavage. A peculiar zonal structure was noted in several instances in which the nucleus of the augite crystal appeared under ordinary light to be light green in color while the outer rim was of a light yellow. This is probably due to a differing chemical composition in the outer rim and inner nucleus. Occasionally the augite was slightly decomposed, but to a certain degree retained its crystallographic form and optical properties. A close examination of it shows some additional interesting features. Included in the porphyritic augite occur small prisms of brown hornblende identical with that to be later described as the principal component of the rock. While the vertical axes in the two minerals appear to be parallel the others do not

(1) *American Journal of Science*, iii series, vol. xxxv, March, 1888. We have been much assisted by Mr. Walcott's map, and by notes kindly loaned by Dr. J. Francis Williams, of the Pratt Inst., Brooklyn.

correspond and the extinction for each occurs at a different point. It would seem from this that the small basaltic hornblende crystals were first to form and that they then became involved in the large augite crystals whose period of generation marks a later stage.

The close intermingling and association of hornblende and augite constitute one of the most interesting and striking features of many rocks. The relations of the two have often led to the conclusion that the hornblende had resulted by paramorphism from original augite. Hawes,[1] Irving,[2] Van-Hise,[3] Williams,[4] Herrick,[5] Hobbs,[6] Lawson,[7] and G. F. Richards,[8] have remarked it in this country and such conclusions seem the ones generally to be drawn. Less often the two are related as in the present instance, in which the hornblende is undoubtedly of older age than the augite and has been afterward taken up in its mass. Teall[9] has noted this in England, and the senior author[10] of the present paper previously in this country.

In addition to the above mentioned porphyritic crystals of augite (which range from 0.5 m.m. to 15 or 20 m.m.) are found other irregular masses of the same mineral. These present no crystallographic outline and were doubtless formed by a second generation later than the porphyritic type. In both, included magnetite occurs in small octahedra.

The hornblende is the most abundant and most characteristic component of the rock. It exhibits minute rod-shaped crystals 0.1 m.m. broad by 0.5 m.m. long, of the basaltic type. Although the faces of the prism zone are well developed as shown by frequent cross sections, the terminal faces are lacking. Their fractured condition is probably due to move-

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[1] G. W. Hawes, *Geol. of N. H.*, vol. III, pp. 57 and 206, pl. VII, fig. 1.
[2] R. D. Irving, *Geol. of Wis.*, vol. III, p. 170.
[3] C. R. VanHise, *Am. Jour. Sci.* (III) XXVI, 29.
[4] G. H. Williams, *Am. Jour. Sci.* (III) XXVIII, 259. In this paper will be found also many references to occurrences of the same phenomena abroad.
[5] C. L. Herrick, *Bull. of Lab. of Denison Univ.*, Granville, O., vol. II, p. 130.
[6] W. H. Hobbs, *Bull. Mus. Comp. Zool.*, Harvard, Univ., vol. XVI, No. 1, p. 10.
[7] A. C. Lawson, *Proc. Can. Inst.*, Toronto, Apr., 1888, p. 176; also *Amer. Geol.*, Apr. 1888.
[8] G. F. Richards, *Bull. Denison Univ.*, vol. IV, p. 6.
[9] J. J. H. Teall, *Quart. Jour. Geol. Soc.*, vol. 40, p. 653.
[10] J. F. Kemp, *Am. Jour. Sci.* (III) XXXVI, p. 250.

ment previous to the complete solidification of the rock. They are highly pleochroic c=b> a. The individual crystals vary little in size, the average being about 0.1 m.m. In some portions of the dike the hornblende has undergone marked decomposition, the product being a greenish mineral resembling chlorite. In one instance, (Stat. M.) every constituent had undergone decomposition. Magnetite occurs original and secondary. In the former octahedral forms were shown included in the porphyritic constituent and varying in size from .02 m.m. to .04 m.m. while the latter appears only in strings of fibrous aggregations. The plagioclase occurs in small rod-shaped crystals in many cases very much decomposed; where fresh ones were noted they did not exceed 0.5 m.m.

While in the region specimens were also obtained by Mr. Marsters from a dike 3 feet in width which cuts the marble quarries two miles south of Proctor[1] on the Rutland and Burlington R. R., some 25 miles northeast of the dikes mentioned above. The macroscopic character is similar and the mineralogical composition is shown by the microscope to be the same in all respects as those described above. Slides of the marble adjoining the dike exhibit a very finely granular mass of calcite crystals, but no special contact minerals or phenomena.

This marble belongs to the Eolian group of Hitchcock,[2] but is referred to the Chazy, etc., by Walcott. It will be noted that it is of later age than the Georgia slates and if this dike belongs, as its similar character would suggest, to the same time of formation as the others, this would be subsequent to the deposition of the Trenton series.[3] We are disposed to connect them with the general upheaval of the Green mountains which closed the formation of the Lower Silurian system.

The chemical composition of these dikes is shown by the analyses of the accompanying table. By way of comparison three other typical Camptonites are appended: (See p. 101.)

The especial interest of these rocks lies in the fact that they establish an additional occurrence of the pure Camptonite type

[1] Mr. Marsters is greatly indebted to Mr. Taylor, of the Proctor Marble Works for assistance given in finding this dike.

[2] *Geol. of Vt.* vol. 1, pp. 399-397.

[3] Using this and other terms in the sense proposed by the International Geol. Congress. (See Rept. of Amer. Com., 1886, p. 50).

as first described by Hawes.[1] Similar ones have been subsequently brought out by Harrington[2] and Kemp.[3] J. J. H. Teall[4] has also described a dioritic type of rock which forms dikes piercing quartzites and limestones in the Scottish Highlands. From the description we should infer that it is similar to the Camptonites. Slides from all of the American localities have been compared in the preparation of this paper and they are strikingly alike. They have also been compared with slides of nearly all the other dikes so far described in this country, chips or slides from which have in most cases been kindly given or loaned by their describers.[5] As compared with these they are different and individual. It is therefore here advocated that the name Camptonite be restricted to dike rocks consisting especially of brown basaltic hornblende in rod-shaped crystals, and of plagioclase and magnetite, together with which augite may or may not be associated.

	Fairhaven. (Kemp.)	Proctor. (Kemp.)	Campton, N. H. (Hawes.)	Montreal. (Harrington)	Forest of Dean, N. Y. (Kemp.)
SiO_2	43.5	41.0	41.94	40.95	48.19
Al_2O_3	7.02	21.36	15.36	16.45	16.79
Fe_2O_3	3.68	13.44	3.27	13.47	18.37
FeO			9.89		
MnO			0.25	0.33	
TiO_2			4.15	3.39	
CaO	8.15	10.4	9.47	10.53	6.85
MgO	6.84	3.85	5.01	6.10	1.32
K_2O	3.02	1.31	0.19	1.28	1.11
Na_2O	2.84	2.86	5.15	4.00	5.59
P_2O_5				0.29	
CO_2			2.47		
Loss on Ign.	4.35	5.00	3.29	3.84	2.31
Total,	99.40	99.22	100.44	100.63	100.53

The writers purpose during the coming summer to study the dikes recorded as so plentiful near Burlington, Vt., and to establish in connection with them such further typical fea-

[1] *Am. Jour. Sci.* (III) vol. XVII, p. 147.
[2] *Geol. Sur. Canada*, 1877-78, p. 439.
[3] *Am. Jour. Sci.* (III) vol. XXXV, p. 331, 1888. *Am. Naturalist*, Aug. 1888.
[4] *Geol. Magazine*, 1886, p. 346.
[5] Emerson. Franklin Furnace mica-diabase. *Am. Jour. Sci.* (III) vol. XXIII, p. 376-380, 1882. Haworth, Missouri dikes. *Am. Geol.*, May-June, 1888. Hobbs. Summerville dike; *Harv. Bull.* XVI No. 1, and others.

tures as may lead to a better understanding and more accurate classification of this confessedly the most obscure group of the massive rocks.

We have been unable in the cases which have come under our own attention to establish any connection between these dikes and any great parent body of eruptives, although the existence of such is to be surmised. We are inclined to think that the walls must have been themselves within a zone of high temperature in order to admit of the penetration of such narrow bodies so great a distance from their source.

Geological Laboratory, Cornell University.

NOTICE OF SOME NEW AND REMARKABLE FORMS OF CRINOIDEA FROM THE NIAGARA LIMESTONE AT ST. PAUL, DECATUR COUNTY, INDIANA.

By CHARLES S. BEACHLER.

The limestone exposed at St. Paul, Ind., is a hard crystalline limestone attaining a maximum thickness of about fifty feet, over-laid by cherty layers intercalated by thin limestone layers.

The only fossils heretofore found were large specimens of *Orthoceras simulator* Hall, *Orthoceras annulatum* Sowerby and *Gyroceras elrodi* Sowerby, until about three years ago a small crinoid over-looked perhaps on account of its size, was found and described as *Pisocrinus gemmiformis* S. A. Miller. This species was the only crinoid that had ever been found by the many collectors until recently when Mr. A. C. Benedict found a peculiar pear-shaped crinoid about twice the size of a grain of wheat. This specimen will probably be described by Messrs. Wachsmuth and Springer.

The following is what Mr. Wachsmuth says in regard to this crinoid. "There is nothing about it to indicate it to be a crinoid and no pores or rhombs to make it a cystid."

This crinoid has since been found by Drs. J. W. and Frank Howard, and the writer.

The crinoids are found only on the weathered edges of this hard crystalline limestone, which makes them hard to see and very hard to chisel out. The largest collection of these small crinoids has been made by Dr. Howard.

While at St. Paul the writer collected three crinoids which had not been found by Dr. Howard while making his collect-

ion; these were turned over to Messrs. Wachsmuth and Springer for description.

Dr. Wachsmuth says that "some of the specimens are upper Devonian or Subcarboniferous forms." The presence of the *Pisocrinus gemmiformis*, which is restricted to the Niagara, the presence of many cystids, and other Niagara fossils prove that these crinoids are of the Niagara limestone.

This limestone can be traced from St. Paul, along Flat Rock to the place where the celebrated Waldron (Niagara shales) beds overlie this limestone; farther up the stream on Little Flat Rock the writer was shown a deep hole in the bed of the stream where the Hudson river shales have been reached and found to underlie this limestone; this proves clearly that the crinoids are Niagara although they resemble later forms. One remarkable fact is that these crinoids do not run through the over-lying shales.

Dr. Frank Howard, however, found in this limestone a cystid about the size of a hen's egg, while Dr. Washburn, of Waldron, also found the same species of cystid in the shale on Conn's creek.

Many facts are yet to be worked out, which may result in many discussions between the paleontologist and stratigraphical geologist.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Obsidian Cliff, Yellowstone National Park. By JOSEPH P. IDDINGS. Pages 249-295; plates ix-xviii. (Accompanying the seventh annual report, U. S. geological survey.) The widely famed Obsidian Cliff, extending half a mile and rising 150 to 200 feet above Obsidian creek, which flows at its base, is situated about eleven miles south of the Mammoth Hot Springs, at an elevation of 7,500 feet above the sea. Its upper half is a vertical face of black obsidian, or volcanic glass, which has resulted from the rapid cooling of a perfectly fused, igneous rock, and the lower portion is a talus slope of the same material. The cliff presents a partial section of a surface flow of obsidian which poured down an ancient slope of rhyolite from the plateau lying to the east. Following the obsidian back from the face of this cliff up the hummocky surface it becomes filled with gas cavities and passes into banded pumiceous rock and finally into light-gray pumice.

A remarkable columnar structure, similar to that of basalt, is developed in the southern part of this cliff, where the obsidian flow had more than its average thickness. The shining black columnar prisms rise from the top of the talus slope to a height of 50 or 60 feet and vary

in width from two to four feet near the end of the cliff, the width of each column being quite constant throughout its length. The prisms have no uniform number of sides, four, five and six being those most frequently observed; the sides are unequally developed, but at a distance the general effect is quite regular. The author thinks that the exceedingly rare occurrence of columnar structure in obsidian is probably owing to the fact that the conditions favorable for the production of prismatic structure and also for the solidification of the lava as amorphous glass are seldom coincident, the cause of columnar structure being unquestionably the shrinkage of a homogeneous rock which is cooling at a moderate rate from its surface.

The rock forming the lower part of the columns is dense, black obsidian, with thin lithoidal bands or layers of spherulites, which range from microscopic size to an inch or more in diameter, having a radially fibrous internal structure. Higher up the rock is less massive and contains lithophysæ, as hollow spherulites are called. The lithoidal rhyolite into which the obsidian passes northward contains a multitude of lithophysæ of the utmost delicacy and beauty, ranging in size up to a foot or more in diameter. Most of them are hemispherical and consist of a group of concentric shells which curve one over another like the petals of a rose. The partition walls are generally very thin, and often close together, in one instance fifty occurring within a radius of two inches. They are very fragile and crumble under the touch, being made up of small and slightly adhering crystals with brilliant, glistening faces.

Analyses show that the chemical composition of the spherulite is essentially the same as that of the surrounding rock, being a small portion of the magma which has crystallized with a particular structure; and, further, that the lithophysæ have the same composition as the dense spherulites, which shows that the transformation of a spherulite to a lithophysa can only be a modification of its structure, a rearrangement of its minerals, without any chemical addition or loss. The conclusion reached by Mr. Iddings, from his very thorough investigation, is that the lithophysæ in the obsidian, with their contents of prismatic quartz, tridymite, adular-like and tabular soda-orthoclase, magnetite and well crystallized fayalite, are of aqueo-igneous-origin and result from the action of absorbed vapors upon the molten glass from which they were liberated during the process of crystallization consequent upon cooling, since which time no alteration, chemical or mechanical, has taken place.

Report on the geology of Martha's Vineyard. By NATHANIEL S. SHALER. Pages 297-363; plates xix-xxix. (Accompanying the seventh annual report, U. S. geological survey.) The island of Martha's Vineyard belongs to an extensive fringe of low land, mainly composed of glacial and modified drift, which borders the continent from New York city to cape Cod. The part of this belt of glacial deposits which is above water is composed of an outer series of drift ridges which

form Long Island, Martha's Vineyard, Nantucket and a number of lesser islands, and an inner ridge evident in cape Cod, the Elizabeth islands and several smaller islands. The eastern portion of this double coast fringe is separated from the western portion by a considerable gap, that which divides Martha's Vineyard from Block island and Long island. The cause of this break is not perfectly clear, but professor Shaler regards it as probably due, not to any failure of the glacial deposits to be formed in this space or in any considerable degree to their erosion, but rather to the fact that the floor on which they rest was originally lower in this part of the coast than elsewhere. This is indicated by the circumstance that from the western end of Martha's Vineyard there is a shoal that extends to Block island and thence to Long island. This shoal seems to be a continuation under water of the marginal drift formations which are so prominently exhibited on Long island and Martha's Vineyard.

These drift deposits comprise (1) the ordinary ground moraine or till, left by the melting of an ice-sheet; (2) frontal moraine deposits, formed where the materials have been pushed before the glacier; (3) kame deposits, where the materials have been brought to their position by the action of violent currents of water operating near the ice front; and (4) terraces or plains, sloping southward from the belt of the frontal moraine and kames.

The total amount of detrital material in the belt of moraines on the northwest part of Martha's Vineyard between Gay Head and Tashmu pond is greater than in any other deposit of this nature known to the author in New England. On an area ten miles in length and one and one-half miles in width the drift can not be on an average less than 150 feet thick. Its highest elevation is Prospect hill, which rises about 300 feet above the sea. South of the hilly morainic belt on the eastern half of the island the surface passes rather suddenly into a plain of gravel and sand, which sinks from an elevation of 50 feet bordering the moraine to only about 10 feet above the sea level at the southern shore of the island.

Professor Shaler believes that the deposition of both the fronta moraine and the bordering plain took place at some depth below the level of the ocean, the relative hights of land and sea in that region having been so changed during the glacial period that even Prospect hill was submerged. This opinion, however leads to a startling conclusion which is stated as follows: "The emergence of the drift deposits of this district from the sea must have taken place with singular rapidity, for there is no sign of wear on the surface of the moraines or the lower-lying kames, such as would inevitably have occurred if their surfaces had been exposed to the action of the waves for any length of time. Nothing save an exceedingly sudden uplift could have secured their escape in the process of elevation; their extremely delicate outlines could not endure the action of the sea for a single month."

But the absence of marine fossils to prove the supposed submergence, and the difficulty thus fully recognized by the author, seem to make it far more probable that the drift deposits were formed above the sea, and even when this district stood somewhat higher than now, which is the opinion of Elias Lewis, Jr., and of Upham, based on the occurrence of ancient channels of drainage, which extend southward from the moraine across the plain and continue beneath the present sea level.

Plentiful fragments of a reddish sandstone, which contain six or eight well marked species of Cretaceous mollusca, are found upon small areas in two places, indicating the existence of Cretaceous beds beneath the drift at no great distance.

The very interesting Tertiary section of Gay Head is described as showing a great number of thick, steeply inclined beds of sand, clay, and lignitic matter of extremely vivid and contrasted colors, with an observed total thickness of about 2,000 feet. The colors range from the dazzling white of the sandy beds to the nearly pure black of the carbonaceous layers, with intermediate hues of brown, green, yellow and red. But the ordinary arrangement of the beds in the section is greatly marked by the continued slipping of large wedges of the deposits down the steep incline of the talus. The fossils of this locality, indicating later Miocene or Pliocene age, are to form the subject of a separate memoir. From the great thickness of these beds and adjacent parts of the same formation, chiefly monoclinal, dipping to the northeast with strike from northwest to southeast, and from the many enclosed lignitic layers the author suggests, with much probability, that the whole formation, denominated the Vineyard series, was the delta of a great river flowing eastward to this area from the Connecticut valley, or perhaps from no further distance than the Narragansett basin, that is, the region now occupied by the Taunton and Providence rivers and their tributaries.

The Ice-age in North America. By G. FREDERICK WRIGHT. (D. Appleton & Co., N. Y. pp. 622, Roy. 8vo, many maps and illustrations, $5.00.) The author of this work has been known for fifteen years as an active student of glacial phenomena, and as such has made extended observations, reaching from New England to Minnesota and the glaciers of Alaska. While his professorial work has been in a far different field,* he has industriously devoted his summer months to glacial geology, and has seen with his own eyes most of the important phenomena of the ice-age in America. While this wide observation has qualified him to use his own language in describing the drift that characterizes so much of North America, and for making judicious selections, and for framing a consistent treatment of his theme, he has preferred to quote largely from the published accounts of other geologists.

The book has chapters entitled: What is a glacier? Existing gla-

*Mr. Wright is professor of NewTestament Greek in Oberlin Theological Seminary and editor of the *Bibliotheca sacra.*

ciers on the Pacific coast, A month with the Muir glacier, Glaciers of Greenland, Glaciers in other parts of the world, Signs of glaciation, Boundary of the glaciated area in North America, Depth of ice during the glacial period, Terminal moraines, Glacial erosion and transportation, Drumlins, Preglacial drainage, Drainage of the glacial period, Kames, Glacial dams, lakes and water-falls, The loess, Flight of plants and animals during the glacial period, The cause of the glacial period, The date of the glacial period Man and the glacial period, with an appendix by Warren Upham on Probable causes of glaciation, and another giving the recent observations of Mr. R. Chalmers On the glaciation of eastern Canada. The work has 143 figures, maps and other illustrations, many of them new, and many from photographic views reproduced in "half-tone." It is faultlessly printed on heavy smooth paper, thus exhibiting at once in the text and in the prints of photo-illustrations, a creditable specimen of American publication.

It would be impracticable to give here a digest of this book. Suffice it to say that the author contrives, after a simple introduction of the reader to a glacier, to lead him through an easy succession of steps to a conception of the *ice-age*, its signs, its results, its date, its cause, &c., and by a wonderful panorama of illustration, accompanied by a panoramic textual description, to give him not only an adequate concepion, but a conviction of the verity of the ice-age. To the author the relation of the ice age to man, and the date of his existence on the earth, has given zest to all his labor, and naturally the chapters which relate to the antiquity of man are specially full and complete.

Geologists in America will welcome this excursion of the theologian into actual science, for they are yet prone to believe that truth to the mind of a theologian is as convincing as to the mind of a scientist, and they only wish that with a similar candor, and thoroughness all theologians would investigate the conclusions of geology before condemning them.

Specifically, while the author agrees with the majority of geologists in nearly all points, there are a few divergences of opinion, viz: Prof. Wright is disposed to regard the entire phenomena of the ice-age as referable to one period instead of two or more, but supposes that the ice-margin advanced again, and perhaps twice or thrice, after the recession began, the "inter-glacial" epochs being no longer perhaps than one or two centuries.

As to the cause of the glacial period, Prof. Wright leaves it an open question. He qualifiedly rejects the eccentricity theory of Mr. Croll but alludes favorably to local elevation of large areas in North America particularly in the Mississippi valley, the Canadian highlands and the New England coast, though hardly allowing this to be sufficient to produce a glacial period. The chief obstacle to the acceptance of Croll's eccentricity theory is the accumulating evidence of the recentness of the last glacial epoch, though this does not interfere with Mr. Croll's resort to precession of the equinoxes to account for general gla-

ciation, but rather confirms that part of Mr. Croll's astronomical theory since the time required for the glacial epoch in both cases is not far from ten thousand years.

Mr. Upham's survey of the evidence of local, continental or regional elevation in North America, in Appendix A. is interesting and valuable; and as a result he accepts the Lyellian hypothesis that such fluctuations have caused not only changes in the distribution and area of land over the surface of the earth, but also have been the prime cause of the glacial epoch. "Briefly stated, the condition and relation of the earth's crust and interior appear to be such that they produce in connection with contraction of the earth's mass, depressions and uplifts of extensive areas, some of which have been raised to hights where their precipitation of moisture throughout the year was almost wholly snow, gradually forming thick ice-sheets; but under the heavy load of ice subsidence ensued, with correlative uplift of other portions of the earth's crust; so that glacial conditions may have prevailed alternately in the northern and southern hemispheres, or in North America and Europe, and may have been repeated after warm interglacial epochs." This is a broader and a more flexible application of the Lyellian hypothesis, and appeals to well-known terrestrial movements, influenced by terrestrial agencies. It goes further than the assumption of elevation, in that it accounts for the elevation. As a theory for terrestrial glaciation it is not new, but the hypothetical manner of application and distribution of the supposed cause for such glaciation appears to be new, and as such deserves the attention of glacialists and physicists.

The Bulletin of the American Museum of Natural History, VOL. II, No. 2, was issued in March 1889 and fully maintains the high reputation of the series to which it belongs. The geological papers are by Prof. R. P. Whitfield, four in number, and are respectively entitled *Observations on some imperfectly known fossils from the Calciferous sandrock of Lake Champlain, and descriptions of several new forms; Additional notes on Asaphus canalis, Conrad; Description of a new form of fossil Balanoid Cirripede, from the Marcellus shale of New York; and Note on the faunal resemblance between the Cretaceous formations of New Jersey, and those of the Gulf states.*

Discovery of Cretaceous Mammals by Professor O. C. Marsh. (Appendix to *American Journal of Science*, July, 1889.) The great break in the geological history of mammals, due to the apparent absence of mammalian remains in any authentically recognized deposits of Cretaceous age, has long been one of the strangest and most inexplicable of the facts confronting the student of palæontology. Small marsupial mammals are known from numerous specimens in the Triassic and Jurassic, both of Europe and America. Mammals, more or less specialized, and fully differentiated into distinct orders, swarmed in the forests and haunted the lake margins in the earliest Tertiary; mammals must have existed during the Cretaceous. It was during the Cretaceous that all the differentiation seen among the early Tertiary mammals

took place. Why have not the remains of Cretaceous mammals been discovered? It is not enough to say that all the Cretaceous deposits accessible to geologists were laid down in the open sea in situations where mammalian remains were not likely to be carried. Such a statement is no longer true. The Dakota group with its leaves of phænogamous forests in the lower horizon of the Cretaceous of the Upper Missouri, and the Laramie group at the close of the period, were laid down under circumstances in all respects favorable for receiving and preserving mammalian remains. Moreover the skeletons of *Dinosauria,* which were as terrestrial in habit as ordinary mammals, are represented in Cretaceous strata by abundant and well preserved specimens. The Zeuglodon did not acquire its adaptation to marine life suddenly. It must have had aquatic predecessors whose remains are entombed somewhere in strata of the later Cretaceous.

As professor Marsh well says: "A comparison of mammals known from the Jurassic and Tertiary made it almost certain [we would say quite certain] that many intermediate forms must exist in the Cretaceous, and their discovery was one of the prizes held out to explorers."

The paper before us marks an important epoch in our knowledge of the history of mammalian life. It contains the first intimation we have had of it finding of unquestioned mammalian remains in strata of Cretaceous age. The finding of such remains is so far confined to the Laramine group, a group by the way that has by excellent geologists, been referred to the lower Tertiary, although its relations to the Cretaceous will now be generally acknowledged. A long breach in mammalian history still remains to be filled, but now that an entrance into this long sealed portion of the mammalian record has been secured we may hope that discoveries will follow each other in quick succession.

The mammalian remains described by professor Marsh were found by Mr. J. B. Hatcher in Wyoming and Dakota, and were associated with *Hadrosaurus* and other *Dinosauria.* They are not exactly what we might reasonably expect the mammals of the Laramie group to be, for they are all rather small creatures, more nearly related to the mammalian fauna of the Jurassic than of the Tertiary; most are marsupials but some have structures indicating relationship with monotremes, a fact of great interest and significance. Seventeen species are noted, and these, together with others from the same horizon, will be fully described and figured in a memoir on mesozoic mammals, now in process of preparation, and to be published by the United States geological survey. Four plates illustrate the article here under consideration.

The Invertebrate Fauna of the Hawkesbury–Wianamatta Series of New South Wales. By Robert Etheridge, Jr. This quarto publication embracing 21 pages and one plate is the first of the palæontological memoirs of the geological survey of New South Wales. S. C. Wilkinson, F. G. S., &c., is the geological surveyor-in-charge.

The series of rocks here named the Hawkesbury-Wianamatta series

lie above the productive Coal Measures of New South Wales and are divisible into four well marked lithological divisions. Proceeding downwards these divisions are Wianamatta shales, 700 feet; Hawkesbury sandstones, 1,000 feet; Marrabeen shales, 650 feet; Estheria shales, 640 feet. The Wianamatta shales are chiefly argillaceous deposits resting in denuded hollows and on worn surfaces of the Hawkesbury sandstone and containing remains of plants, fishes and labyrinthodonts. The Hawkesbury sandstones afford numerous remains of plants and of fishes, but the chief interest centres in two species of labyrinthodonts. One is supposed to be identical with the European Triassic *Mastodonsaurus robustus*, the other is the *Platyceps wilkensoni* Stephens. The lower member of the series contains remains of *Estheria*. The plants of the series as well as the labyrinthodonts indicate the horizon of the European Trias

For some time *Estheria* was the only genus of invertebrates known from the Hawkesbury-Wianamatta series, but recently the invertebrate fauna of the series has been enriched by the discovery of two species of the genus *Unio*, two species of a new genus described by the author as *Unionella*, and a gasteropod belonging to the genus *Tremanotus*. On this continent, and the same is true of Europe, *Tremanotus* is not known after the close of the Upper Silurian. It is a matter of no small degree of interest to find this old fashioned genus reappearing in Triassic strata in New South Wales.

Contributions to the Tertiary Flora of Australia. By Dr. Constantin, Baron von Ettingshausen. This volume constitutes the second of the palæontological memoirs of the geological survey of New South Wales. In addition to the description of genera and species the author discusses the relations between the Tertiary and modern floras of Australia, the relation of Australian types in the Tertiary flora of Europe to similar types in the Tertiary strata of Australia, and the question whether not exclusively Australian forms can be traced in the Tertiary flora of Australia. "The Tertiary flora of extra-tropical Australia is, as regards character, essentially distinct from the present living flora of Australia, nor does it closely resemble in general, any living flora. On the other hand it shows the mixed character of the Tertiary floras of Europe, the Arctic regions, North America, and probably all the Tertiary floras. It has also much more similarity to the Tertiary floras at present known than to the existing flora of Australia.

The author points out that the Tertiary floras wherever studied combine all the elements of the modern floras. For example genera now exclusively confined to the Australia region, occur in the Tertiary of Europe, while on the other hand the genus *Quercus* is represented by a number of species in the Tertiary flora of Australia, though not represented at all in the modern flora. Palæo-botanists can readily point out similar examples from a comparison of the Tertiary floras of Europe and North America. During the Tertiary, as the author well

says, "types of plants existed together which are now separated from one another by large tracts of the earth's surface." In the Tertiary of Java for example occur the well known North American genera *Cornus*, *Rhamnus* and *Ceanothus*.

An interesting feature of the volume is a table showing a comparison of the Tertiary flora of Australia with other Tertiary and the existing floras. The table brings out, in a very striking way, the similarity characterizing all Tertiary floras. The larger part of the volume is necessarily devoted to the description of genera and species. Fifteen plates, crowded with beautifully lithographed figures, illustrate the text.

Records of the Geological Survey of New South Wales, Vol. I, Part I. This pamphlet of 31 pages and 5 plates contains seven short articles on subjects relating to the work of the survey. The second article reports the discovery of human remains in the sand and pumice bed at Long bay, near Botany. The geological conditions and associated objects indicate an interment in Post-Tertiary times. At the same time all evidence points to a high antiquity, so that the burial probably dates back to the earliest human occupation of the region. The fourth article describes and illustrates a coral intermediate between the genera *Lonsdalia* and *Spongophyllum*.

On the classification of the early Cambrian and pre-Cambrian formations. A brief discussion of principles, illustrated by examples drawn mainly from the Lake Superior regions. By R. D. IRVING. Pages 365-454; plates xxx—li; figures 64-96. (Accompanying the seventh annual report of the director of the U. S. geological survey.)

No other geologist has so thoroughly explored and studied the region adjoining lake Superior as the late professor Irving, and this paper, one of the last prepared by him, presents a very clear and comprehensive statement of his conclusions concerning the stratigraphic divisions and relationships of its Cambrian and older formations. The paper treats mainly of the extent to which paleontological and lithological characters, unconformities, and intervals attended by extensive erosion, are respectively to be relied upon for purposes of classification Incidently, it includes many sections and details of the stratigraphy of localities which illustrate the principles under discussion, with geological maps of central Wisconsin, northeastern Minnesota, and the Penokee-Gogebic iron region in northern Wisconsin, and northwestern Michigan.

Four great groups or series of rocks are recognized in the Lake Superior region, divided from each other by unconformity and erosion, namely, in descending order, the Cambrian, Keweenawan, Huronian, and Laurentian. In the more general classification of these divisions, professor Irving believed that only the Laurentian should be included in the Archæan system, "because of the greatness of the time interval between that series and the next succeeding it, in comparison with any of the later interruptions of the geological column; because of its in-

tensely altered condition and generally unique characteristics, as compared with those of any of the later groups; and because of the lack of definite evidence of the existence of life during its production, while life plainly existed at the time of deposition of the earliest of the succeeding groups."

The Huronian and Keweenawan, with perhaps other groups to be hereafter established, intervening between the Laurentian and Cambrian, are classed together as Agnotozoic or Eparchean, this term being subject to future limitation or entire replacement, if any sufficiently distinctive paleontological discoveries shall be made. Professor Irving's classification draws the line between the Agnotozoic and Paleozoic systems at the base of the Potsdam, Saint Croix, or Lake Superior, sandstone in the succession of formations developed about lake Superior; but he suggests that sufficient evidence may yet be found in Keweenawan and Huronian fossils for the extension of the Paleozoic system to include all these groups, excepting the basal Laurentian gneisses and schists.

The structure of the Triassic formation of the Connecticut Valley. By William Morris Davis. Pages 455-490; plate iii (map of a portion of Connecticut); figures 97-108. (Accompanying the seventh report, U. S. geological survey.)

The present extent of this Triassic area measures about 95 miles north and south, from long Island sound, where it runs under the sea, nearly to the northern boundary of Massachusetts, and from 15 to 18 miles east and west in central Connecticut and southern Massachusetts where it is broadest. The aqueous rocks of the formation consist of conglomerates, sandstones, and shales; they are mostly of a red or brown color but the shales are sometimes dark and bituminous, with impressions of fish and of land plants; occasional thin seams of coal have been reported, and a small but significant bed of impure grayish limestone makes its appearance among the shales.

Interbedded with these sediments are dolerites or diabases, which occur as intrusive sheets along the western border of the southern half of the formation, and elsewhere and more commonly as overflows, lying upon the beds that had been formed at the time of their eruption and buried under the later deposits.

A preliminary statement of the sequence and thickness of the Triassic series in the Connecticut valley, in natural order from top to bottom, is as follows:

	Thickness in Feet.
Conglomerates, sandstones, and shales	2,000 to 3,000
Posterior trap overflow	50 to 150
Sandstones and shales	300 to 500
Main trap overflow	300 to 500
Shales with thin limestone	100 to 300
Anterior trap overflow	50 to 150
Shales	500 500
Shales, sandstones and conglomerates	3,000 3,000
Intrusive trap sheet	200 to 400
Sandstones and conglomerates	500 to 2,000
Total	7,000 to 10,500

The monoclinal attitude of the formation, with a general eastward dip of twenty or thirty degrees, is found to be due to faults which extend nearly parallel with the strike, having their upthrow on the east in practically all observed cases; but there are departures from the eastward direction of dip in the neighborhood of the curved trap ridges at some other points. In explanation of the mechanical origin of this monocline, the author shows that the disturbance occurred after the deposition of the Triassic beds was essentially completed, and therefore involved the whole thickness of the formation; and that the faults doubtless have depth proportionate to their throw and length, carrying them far down, perhaps many miles, into the underlying schists and gneisses. An ingenious series of diagrammatic sections illustrates how the originally horizontal Triassic strata and the steeply inclined schists beneath have been disturbed by lateral compression, exerted in an east and west or southeast and northwest direction, producing the monoclinal structure and the frequently crescentic forms of the ridges of outcropping trap sheets.

Salt-making processes in the United States. By THOMAS M. CHATARD. Pages 491-535; plates liii—lv. (Accompanying the seventh report, U. S. geological survey.)

This paper treats of the chemistry of brine, and describes the different methods of salt-making employed in this country and the results obtained by them, together with some references to foreign practice. The author concludes that, as a whole, the salt industry of the United States, while conducted with energy and skill, is yet capable of much better work than that done at present. An appended table shows the results of analyses and experiments, made under the direction of Walter R. Johnson of the U. S. navy, testing the heating, evaporating and steam-producing values of thirty varieties of coal from the United States, three from Nova Scotia, and three from Great Britian, also of dry pine wood.

The Geology of the Head of Chesapeake Bay. By W. J. MCGEE. Pages 537-646; plates lvi-lxxi; figures 109-114. (Accompanying the seventh report, U. S. geological survey.)

The specific object of the investigation here reported was to determine the probable success of an artesian boring at Fishing Battery station in Chesapeake bay, near its head, between Havre de Grace and Spesutie island. A detailed map shows the distribution of the Columbia formation in the vicinity of the head of this bay; and another on a small scale shows the drainage of the middle Atlantic slope, with the course of the fall-line, where the streams pass their lowest rapids or falls. This line, which extends close along the northwest side of this part of Chesapeake bay from Baltimore to Port Deposit on the Susquehanna, and similarly along the lower part of the Delaware river from Wilmington to Trenton coincides nearly with the division between the hilly Piedmont region on the northwest, consisting of highly tilted

crystalline rocks, and the low coastal plain of slightly inclined Mesozoic and Cenozoic formations.

Notes of the rock exposures in more than sixty localities within the area of the detailed map illustrate very fully the variable characters of the formations represented, which include alluvium, the Columbia formation, the Sassafras river greensand, the Potomac formation, and the probably Archean crystalline rocks.

A remarkable feature of the entire tract is the general absence of subaerial alluvium. The streams northwest of the fall-line have high declivity and have cleanly swept their channels, while those on the southeast have deposited their detritus either in their own ever-widening estuaries or in the bay. Subaqueous alluvial sands are penetrated to a depth of 140 feet by a boring at Fishing Battery station, with no indication of reaching the base of these postglacial deposits of the Susquehanna and its affluents.

The loam or clay, sand, and gravel of the Columbia formation here represent, as stated by Mr. McGee, "a sub-estuarine delta of the Susquehanna river deposited when the Quaternary ice-sheet reached its southernmost extension, contemporaneous in a general way with the glacial deposits of the north; and they indicate coeval but surprisingly brief submergence of the region, reaching at least two hundred and forty feet and continuing sometime after the retreat of the ice-sheet commenced." According to the author's computation, the time occupied in the deposition of this ancient delta may not have exceeded 1,500 years. It is referred to the earlier of the two principal glacial epochs of the Quaternary, which is believed to have been divided from the later glacial epoch by a longer time than that which has elapsed since the final disappearance of the ice.

The Potomac formation, consisting of clays and sands of early Cretaceous or late Jurassic age, stands next in the order of importance in this study, since the sandstone of its lower part would be the source of artesian water in this district. It is probable that this sandstone occurs beneath Fishing Battery station, but that the overlying clays of the upper part of the Potomac formation had been there eroded, allowing it to be directly overlaid by the less impervious Columbia formation. Therefore it seems doubtful, in view of the imperfection of the confining stratum and of the limited head, whether water reached in the Potomac sandstone would flow, though it would probably rise nearly or quite to the surface.

Along the western border of the coastal plain and the fall line of the streams before noticed, Mr. McGee finds evidence of displacement which has been in progress during the Quaternary and recent period, the area northwest of this line from the Rappahannock to the Hudson being uplifted, and that on the southeast being depressed. The sinking on the seaward side of the line appears to commence in the vicinity of Fredericksburg and to increase northward to 300 or 400 or possibly 500 feet, while the area on the northwest has probably been elevated

to an equal extent. Comparison with fault scarps that have displaced the sediments of the Quaternary lakes Bonneville and Lahontan, in the recent uplifts of the grand Wasatch and Sierra Nevada ranges, indicates that this displacement between the Piedmont region and the coastal plain is not inferior in the amount of change now taking place. But the author supposes that mountain building is in as active progress in the Cordilleran region of western America, and particularly in the Great Basin, as in any country; and accepting that mountain growth as a standard for past ages, he concludes that the present rate of displacement along the fall-line of the middle Atlantic slope is about as high as has ever been attained in any part of the globe during any geologic period. It seems very difficult, however, to account for these movements, as the author endeavors to do, by erosion and deposition subtracting from and adding to the weight of these portions of the earth's crust.

Die Lunzer, (Lettenkohlen), Flora in den "older Mesozoic beds of the Coal Field of Eastern Virginia," von D. STUR: Verhandl. d. k-k. geol. Reichsanstalt, Wien. No. 10, July 1888, pp. 203-217. A smaller collection of fossil plants from the older mesozoic of Virginia, sent last year by the United States geological survey to Dionys Stur, director of the Austrian geological survey, for comparison with the Austrian mesozoic flora, was made the subject of the communication under the above title, submitted last summer to the latter survey.

Since the publication of Professor Fontaine's monograph on the older mesozoic flora of Virginia, Professor Stur has urged the intimate relation between that flora and those of the Lunz beds in Austria, but fearing to rely on the former's illustrations, he has withheld specific conclusions until a comparison of the specimens should have been made. Now, however, as the result of such comparison, he correlates the Virginia beds with the Lettenkohl [Keuper] of Lunz. Following is a list of the Virginia plants so compared, with their equivalents in the Lunz strata, the Clover Hill plants on the left and the Austrian on the right:

Equisetum rogersi, Schimper.	Equisetum arenaceum, Jæger, sp.
Schizoneura virginiensis, Font.	Calamites meriani, Brgt.
Macrotæniopteris magnifolia, Rogers, Sp.	Tæniopteris latior et.
Macrotæniopteris crassinerris, Font.	" simplex, Stur.
Acrostichides linnææfolius, Bunb Sp.	? ?
Acrostichides rhombifolius, Font.	Speirocarpus lunzensis, Stur.
" densifolius, Font.	" rütimeyeri, Heer.
" microphyllus, Font.	" microphyllus, Stur.
Mertensides bullatus, Bunb, sp.	Oligocarpia robustior, Stur.
" distans, Font.	" lunzensis, Stur.

Asterocarpus virginiensis, Font.	Asterotheca meriani, Bgt. sp.
" platyrrhachys, Font.	" " " "
" penticarpus, Font.	" " " "
Lonchopteris virginiensis, Font.	Speirocarpus haberfelneri, Stur.
Clathropteris platyphylla, Font.	Clathropteris reticulata, Kurr.
Pseudo-danæopsis reticulata, Font.	Heeria lunzensis, Stur.
Ctenophyllum braunianum, Font	Pterophyllum riegeri, Stur.
Ctenophyllum grandifolium, Font.	Pterophyllum haueri, Stur.
Podozamites tenuistriatus, Font.	?
Sphenozamites rogersianus, Font	Pterophyllum bronnii, Schenk.

The relations of several other species figured by Fontaine are also discussed, including *Ctenophyllum taxinum*, Font., which he says is identical with his *Pterophyllum cteniforme*. Whatever species shall eventually pass into synonymy, it is clearly no fault of Professor Fontaine's that so many of his species are identical with the new ones of Stur, of which he had no knowledge since the Prodrome of the Lunz flora, all that has yet appeared, and without illustrations, was published in 1885, two years after the publication of Fontaine's monograph. Prof. Stur's discussion shows an evident affinity between the flora of the Richmond coal fields and those of Lunz and Raibl, and the Lettenkohl of Germany, but one can hardly find courage to go the whole length with him in putting as his first and foremost argument the fact that the Clover Hill specimens are so similar lithologically to those of Lunz that those acquainted with the latter would pronounce them as coming from Lunz.

RECENT PUBLICATIONS.

1. *State and Government Publications.*

Report on an exploration in the Yukon district, N.W.T. and adjacent northern portions of British Columbia, 1887, By George M. Dawson. Part B. Annual report, *Geol. and Nat. Hist, Sur. of Canada.* Montreal 1888, Roy. 8vo. 277 pp. Maps and plates.

The mineral wealth of British Columbia, with an annotated list of localities of minerals of economic value. By George M. Dawson. Part R. Annual report, *Geol. and Nat. Hist. Sur. of Canada.* Roy. 8vo. 163 pp., Montreal.

Report of the Director of the Mint upon the production of the precious metals in the United States, during the calendar year 1888.

Notes to accompany a preliminary map of the Duck and Riding mountains, in northwestern Manitoba. By J. B. Tyrrell. (Part E. Ann. Rep. *Geol. Nat. Hist. Sur. Can.* 1887.)

Annual report of the state geologist of New Jersey, for the year 1888. Geo. H. Cook. Octavo, 36 pp.

Description of new genera and species of fossils from the middle Cambrian. *Charles D. Walcott.* (Advance sheets from the Proc. U. S. Nat. Mus., Issued June 11, 1889.)

Bul. N. Y. State Mus. Nat. Hist. No. 7, June 1889, contains Prof Smock's "First report on the iron mines and iron ore districts in the State of New York," with a map showing their distribution.

2. *Proceedings of Scientific Societies.*

The coral reefs of the Hawaiian islands. By Alexander Agassiz, with 13 plates. *Bulletin Mus. Comp. Zool.* vol. XVII, No. 3. April, 1889.

The faults in the Triassic formation near Meriden, Connecticut. By William Morris Davis. *Bulletin Mus. Comp. Zool.* Vol. XVI, No. 4, April, 1889.

Proceedings of the Canadian Institute, Toronto. Vol. XXIV, No. 151. The Caves and pot-holes at Rockwood. Prof. J. Hoyes Panton. Geological formation at Port Colborne. John C. McRae.

Annual Report of the Council of the Canadian Institute. Included in the report of the Minister of Education, Ontario, 1888; consists principally of the illustrated archæological report of the Curator. David Boyle.

Bulletin of the American Museum of Natural History. Vol. II, No. 2, contains observations on some imperfectly known fossils from the Calciferous sandrock of lake Champlain, and descriptions of several new forms, by R. P. Whitfield; Additional notes on Asaphus canalis Conrad, by R. P. Whitfield; Description of a new form of fossil Balanoid Cirripede, from the Marcellus shale of New York, by R. P. Whitfield; and note on the faunal resemblance between the Cretaceous formations of New Jersey, and those of the gulf states, by R. P. Whitfield.

3. *Papers in Scientific Journals.*

Am. Jour. Sci. June No. Topographic development of the Triassic formation of the Connecticut valley. W. M. DAVIS. Analysis of three descloizites from new localities. W. F. HILLEBRAND. New meteorite from Mexico. J. E. WHITFIELD. Contributions to the petrography of the Sandwich Islands. E. S. DANA Allotropic forms of silver. M. CAREY LEA.

Am. Naturalist, Feb. No. On the Permian formation of Texas. CHARLES A. WHITE.

4. *Excerpts and Individual Publications.*

The relations of geology and engineering practice: an address delivered before the engineering students of the Arkansas Industrial University, Oct. 29, 1888. By *Arthur Winslow.*

The United States; facts and figures illustrating the physical geography of the country, and its material resources. Written for, and published in part in the Encyclopedia Britannica (ninth edition). By *J. D. Whitney*; Boston, Little, Brown & Co. 1889.

On the crystal form of metallic zinc. *Geo. H. Williams* and *Wm. M. Burton.* From the American Chemical Journal. Vol. XI, No. 4.

A platiniferous nickel ore from Canada, *F. W. Clark* and *Charles Catlett*, Am. Jour. Sci., May, 1889.

Methods of modern petrography. By *H. Hensoldt*, School of Mines Quarterly. No. 3, vol. x.

Memoir of Dr. Douglass Houghton, first state geologist of Michigan, with an appendix containing reports or abstracts of the first geological survey, and a chronological statement of the progress of geological exploration in Michigan. By *Alvah Bradish, A. M.* Octavo, 302pp., with a portrait of Houghton. Raynor and Taylor, Detroit, Michigan. [See Vol. III, p. 403.]

The distribution of phosphorus in the Ludington mine, Iron mountain, Michigan; a study of isochemic lines. By *David H. Browne.* From the Trans. Am. Inst. Min. Eng., Feb. 1889.

Die Gattung tubicaulis Cotta; bearbeitet von *Dr. Gustav Stenzel.* (From Dr. Geinitz Mittheilungen, Dresden, achtes Heft, 1889.)

Descriptions of new species of fossil Crustacea from the lower Silurian of Tennessee. *J. M. Safford* and *A. W. Vogdes.* (Proc. Acad. Nat. Sci. Phil. 1889.) Author's edition, printed in advance.

On some remarkable organisms of the Silurian and Devonian rocks in Southern New Brunswick. By *G. F. Matthew.* From Trans. Roy. Soc. Can. Sec. IV, 1888, p. 49.

On the crystallization of igneous rocks. By *Joseph Paxson Iddings.* (Phil. Soc. Wash. Bulletin, vol XI, pp. 65-113.)

On the occurrence of fossils of the Cretaceous age on the island of Martha's Vineyard, Mass. By *N. S. Shaler.* (Bul. No. 5, vol. XVI, Mus. Comp. Zool.)

On the volcanoes and volcanic phenomena of the Hawaiian Islands. *James D. Dana.* (with a paper on the petrography of the island, by *Edward S. Dana.*) A collection of recent papers in the American Journal of Science.

Glaciation of mountains in New England and New York. *Warren Upham.* (Appalachia, May, 1889.)

The northern limits of the mesozoic rocks in Arkansas. By *O. P. Hay.* (From vol. II, Annual report, Geol. Sur. Ark.)

5. *Foreign Publications.*

Ueber die chemische Constitution und über de Farbe der Turmaline von Schüttenhofen, von R. Scharizer. Aus zeit. für Krystallographie, Leipzig, vv. 4, 1889.

Om att fynd af uroxe i Rakneby, Ryssby socken, Kalmar lan, jemte bidrag till fragen om tiden för vara subfossila oxarters utdöende, af N. O. Holtz. *Aft. ur Geol. Fören i Stockholm Förhandl.* Bd. x. Höft 7, 1888.

Schriften des Naturwissenschaftlichen Vereins für Schleswig-Holstein. Bd. VII, 2 Heft. Kiel. 1889. Contains: Verzeichniss der in der Kieler Sammlungen befindlichen fossilen Molluskenarten aus dem Rupelthone von Itzehoe nebst Beschreibung einiger neuer und einiger selteneren Formen. *Dr. H. J. Haas.* Ueber zerquetschte Geschiebe. *O. Zeise.*

Mineralogy: By Frank Rutley. 3rd Edition, 16mo, 241 pp. Thomas Murby, London.

Ueber die Erdbeben der kapathen-und-karstländer. Berichte der ungaischen und kroatischen Erdbeben-Commissionen. (In the geol. Mittheil. Zeit. der ungarn, geol. Gesell. Jan.-March, 1889.)

Der Löss von Brünn und seine Einschlüsse an diluvialen Thieren und Menschen. *A. Makowsky*. Verhand.d. nat. Ver. in Brürnn. XXVI, Band, 1888.

Ueber die Vervendung einer Schefelkugel zur Demonstration singulärer Schnitte an der Strahlenfläche; von *A. Schrauf*, aus *Annalen der Physik und Chemie*. Bd. XXXVII, 1889, Leipzig.

The history of volcanic action during the Tertiary period in the British Isles. By Archibald Geikie. 4to 184 pp. Map and woodcuts, Robert Grant and son, Edinburgh; Eighteen shillings. 1888.

Reports of geological explorations during 1887-88, with maps and sections (New Zealand.) By *James Hector*. Embraces also reports by *Alexander McKay* and *James Park*.

Ueber einige Bestandtheile des Meteoreisen von Magura, Arva, Ungarn. Von *E. Weinschenk*; Clintonit aus dem Meteoreisen von Magura, Arvaer Comitat. Von Dr. Aristides Brezina.

CORRESPONDENCE.

NOTE ON THE DISTRIBUTION OF CERTAIN LOESS FOSSILS.—Throughout Iowa and portions of the contiguous states the loess forms a marked feature along the principal lines of drainage. Its characteristic topography readily distinguishes it, at a distance, from associated glacial deposits. Everywhere over the area referred to the loess is to a greater or less extent fossiliferous. With a few exceptions the fossils are shells of mollusca, which are often very abundant, and are easily recognizable, by a peculiar chalky whiteness, from "dead" shells of the same speciess till extant. There are now known from the loess of Iowa about thirty-five species of mollusks. Of these three-fourths are land forms; the remainder aquatic.

The species found in the loess which at present appear to be extinct over portions, or all of the area just mentioned are: *Patula strigosa* Gould, *Pupa blandi* Morse, *Pupa muscorum* Linné, *Vertigo simplex* Gould, *Mesodon thyroides* Say, *Vallonia pulchella* Müller, and *Helicina occulta* Say. It is to be noted that all seven of these gasteropods are terrestrial, and that they are among the most characteristic and persistent forms of the deposit, usually occurring in greater or less abundance wherever the loess is present in the Mississippi Valley. The first four species listed are at the present time extra limitary; *Vertigo simplex*, *Pupa blandi*, and *Pupa muscorum* being boreal forms, the latter also circumpolar in its distribution. The other three species enumerated are not found living in central Iowa. *Mesodon thyroides* Say occurs, however, in the eastern part of the state along the Mississippi river. *Vallonia pulchella* and *Helicina occulta* also are

found only in the northeastern portion of the state. The first of these two is a minute yet hardy species, circumpolar in its geographic range and possessing a high antiquity geologically. The other was, until very recently, known only from fossils. A few years ago it was discovered in considerable numbers living near Iowa City and later in Hardin county, Iowa. The local distribution of the living forms of this species is very remarkable, and in both of the places mentioned it is extremely limited, being scarcely an acre in extent. It thus appears that the once abundant and widely distributed species is now on the verge of extinction.

Attention has lately [1] been called to a striking difference in the facies of the living Unionidæ of central and eastern Iowa, and incidentally to some peculiarities in the distribution of the gasteropods over the same region. Extensive collecting among recent mollusca in various parts of the state revealed that certain species, especially land forms, were less abundant in the western and central, than in the eastern, portions of Iowa; and that some of these forms were much more plentiful towards the northern than towards the southern, limits of the latter district. The occurrence in great abundance, in the loess over central Iowa, of certain gasteropods which are now extinct throughout the tract, and the recent discovery of some of these same forms living in great numbers in the northeastern part of the state, suggested that a part at least of the present molluscan fauna of Iowa was derived from the northeastward; and that the migrations of the mollusks probably began immediately upon the recession of the great ice sheet. The existence of the extensive "driftless" area of southwestern Wisconsin—once an immense island in the great *mer de glace*—afforded considerable plausibility for the inference, but in the absence of suitable material from this region the actual presence of various living mollusca could not be satisfactorily determined. A short time ago, however, some of this material was supplied from southeastern Minnesota. Among the living forms represented were *Helicina occulta* Say, and *Vallonia pulchella* Müller, both from within the limits of the "driftless" tract. The discovery is of great interest as corroborating the supposition already set forth, and it is not unlikely that the first of these two species will be found in other localities in northeastern Iowa and the adjoining portions of the contiguous states; its peculiar and strictly local distribution will, however, tend to render detection quite difficult.

The southern limit of the vast ice sheet of the principal glacial epoch has been made out with an eminent degree of accuracy, and over the Mississippi valley coincides approximately with the Ohio and Missouri rivers. As the ice melted along the front of the retreating glacier, enormous accumulations of glacial silt and dèbris were deposited. But whether the deposition of the loess was contemporaneous with the closing stage of the earlier glacial epoch, as advanced by Chamberlin and Salisbury;[2] or was during the episode immediately succeeding the

[1] Keyes: Annotated Cat. Mollusca Iowa, Bul. Essex Inst., vol. xx.
[2] 6th Ann. Rept. U. S. Geol. Sur., p. 305.

long interglacial period, as urged by McGee[3] is not pertinent. Certain it is, however, that the remarkable abundance and wide geographic distribution of many of the loess shells is indicative of a considerable period, after the recession of the glacier, during which the climate must have been comparatively mild in order that the numerous species of land mollusks could reach such an immense development, and attain such a wide dispersion as is clearly manifest. That the climatic conditions, however, were much more rigorous than at present is amply shown not only by a notable depauperation of the molluscan shells as first pointed out by McGee and Call,[4] but it is also attested by the introduction of many boreal forms, some of which have been already enumerated. The presence, during the deposition of the loess, of arctic species in Iowa is further evidenced by the discovery of the remains of such northern mammals as *Ovibos cavifrons*,[5] and *Cervus muscatinensis*.[6]

The driftless area—formerly a veritable *Jardin* midst a vast waste of ice—is therefore of peculiar interest in considering geographically the faunal distribution during a time when the climatic conditions of the region were manifestly very different from those of the present, and it is not improbable that within the limits of the tract mentioned careful search among the mollusca and plants will yet reveal many significant traces of boreal life—vestiges of an arctic season.

Burlington, Iowa. CHARLES R. KEYES.

THE TACONIC OF EASTERN NEWFOUNDLAND.—Through the kind permission of professor Marcou and the author, Mr. James P. Howley, geologist of St. John, Newfoundland, we are enable to place the following interesting letter before the readers of the GEOLOGIST.

St. Johns, Newfoundland, April 24th, 1889.

PROFESSOR JULES MARCOU.

Dear Sir.—I have read with the greatest interest your pamphlet on "Canadian Geological Classification." Although I am but a field geologist and have neither time nor opportunity for indulgence in theorizing, I can appreciate your work, the more especially since many of your ideas coincide exactly with what I have always believed. For instance, I never could see the sense of representing faults to account for apparent incongruity where no fault was visible, or no facts to sustain such representation. On this head, and indeed on many others concerning which we differed, Mr. Murray and I had frequent discussions. Being a subordinate I was often obliged to give way, but in one or two notable instances where I had clear, indisputable evidence to bring forward, he gave way to me.

On our west coast the Carboniferous series of Newfoundland rests on

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[3] Pop. Sci. Mo., Nov. 1888, p. 26.
[4] Am. Jour. Sci., Sept. 1882, vol. xxiv.
[5] McGee: Am. Jour. Sci., (3), vol. xxxiv, p. 217.
[6] Leidy: Proc. Acad. Nat. Sci., Phila., xxxi, p. 32.

Laurentian and Lower Silurian.[1] In the former instance the absence of all the intervening formations could only be accounted for by Mr. Murray by assuming a gigantic break extending right through the island and bringing the Carboniferous down against the Laurentian, burying the immense thickness of underlying rocks in the gulf of St. Lawrence. In 1873–74, I was sent to survey this section of country and examine it closely. I entirely failed to find the least indication of his great fault anywhere in the region. There was no getting over the fact that it did not exist, and that the Carboniferous rested unconformably both on the Laurentian and Silurian without any such fault intervening. He was convinced of the correctness of my observations and thenceforth removed the line indicating this great break from his maps.

Another observation of yours has also long been held by me, viz.—that there is a great deal more in lithological resemblances than is generally conceded. I always maintained this against Mr. Murray, who never placed much reliance upon it. Of course I do not maintain that it holds good in every case, or that the lithological characteristics of a certain series of rocks in one country can be always taken as a guide to the same series in another. But there are certain well-marked characteristics in almost every formation which become familiar to one who has for a long time closely observed them, which always act as a guide to him, at all events in other sections of the same country. At least I have found it so here. There can be no question that stratigraphy should be more relied upon than it generally is. There are many instances where theory and even palaeontology have had to give way. That reference to Mr. Walcott's recent visit to this country, in your pamphlet is one. It is a great satisfaction to me learn this, for although Mr. Murray commenced the study of those primordial rocks, it was I who really worked them out, visited every locality where they outcropped and constructed the column representing the order of succession of the various strata. I do not maintain that it is absolutely correct in every particular. It would take very much more time than I was allowed to devote to the work to perfect it, and there is nothing that would give me greater pleasure now, than to do so, but unfortunately I am so situated here, where purely scientific work of that kind is so little understood or appreciated, that I dare not devote a season to it. It is from your pamphlet that I learned for the first time that Mr. Walcott has found our stratigraphy to be correct. You are quite right in placing the Topsail Head and Bryer's Head limestones beneath the Paradoxides beds of St. Mary's and Trinity bays. It is

[1] The names Lower Silurian and Silurian are used for the upper and even the middle Taconic. The Potsdam of Great Bell Island of Billings does not belong to the Potsdam of New York, which does not exist in Newfoundland, but seems to occupy the upper part of the column of Primordial strata in the southeastern part of Newfoundland, and is very likely the homotaxis of a part of point Levis and Phillipsburgh groups.—J. M.

also true that a small Lingula is found in a black shale resting immediately upon the limestone in the former locality, though not seen elsewhere in the same position. There are several other Lingulæ in the Bell Island rocks, especially in a white sandstone at the very top of the series. Mr. Billings believed these latter beds to be the base of the Potsdam. If so, they are above all the Paradoxides beds, Topsail Head limestone and Archæocyathus limestones of Trinity bay. They are also above the Eophyton beds of Bell Island.

The Lingulæ of Bell Island are chiefly *Lingulella spissa*, *L. lovenii*, *L. affinis* and *Lingula murrayi*. The former occupies the uppermost strata. All the other rocks of this island are crowded with fucoids, *Cruziana similis*, *Eophyton linnæaum*, *E. jukesi*, and *Anthraria antiquata* are very abundant. In the Kelly's Island rocks which pass beneath those of Great Bell Island, fucoids are also abundant and there is another *Lingula*, *L. billingsiana*. No trilobites have been found on either of these islands as yet.[2] The trilobites are all below and would occupy the intervening space between Topsail Head and Kelly's island. If Mr. Walcott said we had no evidence for this supposition, he was very much astray. We have abundant evidence. In the first place the Manual Creek shales just above the Topsail Head limestone contain numerous small trilobites. The larger trilobites of St. Mary's, Trinity and Fortune bays all underlie strata similar to those of Kelly's and Bell islands, and are seen coming in contact, all conformably related. I know of no *Olenellus* in any of these strata, unless Mr. Walcott has found such last year. The only *Olenellus* I remember occurs in a pinkish limestone at Canada bay on the northern peninsula of the island, far removed, and evidently having no connection with the Conception bay primordial strata. These *Olenelli* were long ago referred to the Potsdam by Mr. Billings and are just beneath a heavy outcrop of Calciferous. There is nothing approaching Calciferous anywhere on the southern or eastern portion of this island, from Cape Ray to Cape Freels.

Now for a few words with regard to the so called Quebec Group in Newfoundland. I have also had much to do with that, and Mr. Murray and I held many conversations on the subject of its true position. Of course he always endeavored to reconcile everything with the structure as laid down in Canada, but this was a very difficult task. Whatever the serpentines and their associated rocks may be, whether igneous, metamorphic or whatever else, I am confident that in one locality at least in this country they rest unconformably upon Calciferous, Levis and Sillery.[3] In 1874 I surveyed the Port-au-Port bay and gave the exposures there the closest possible scrutiny. On

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[2] Fragments of trilobites occur on Great Bell Island.—J. M.

[3] The name Calciferous used here, does not mean that it is the equivalent of the Calciferous of New York, but only that Billings has called the Pointe Lévis and Phillipsburgh groups Upper Calciferous in Newfoundland. It is an erroneous synchronism. In western Newfoundland Mr. Howley has found the Georgia group with *Olenellus thompsoni*, directly under the Point Levis group.—J. M.

my return I submitted my work with sections, etc., to Mr. Murray. It was as clear as daylight that not only the Calciferous and Levis passed beneath the serpentine group, but the Sillery also. The latter was found in several places resting quite conformably on the Levis shales with their graptolites, and always passing beneath the serpentines, dolomites, etc. while the latter were found to rest on various members of the lower formation quite unconformably. Mr. Murray was very reluctant to admit that the Sillery (always placed above the Louzon) could really hold an inferior position; but when he became convinced of the fact and also of the unconformity, he grew quite enthusiastic. Here was at all events a direct disproval of the attempt to place the serpentines in a far inferior position. He wrote to Sir William Logan, then in England very ill, and sent my notes with the maps and sections. Sir William, after a careful study, was satisfied with the correctness of the work, and in one of the last letters he ever wrote Mr. Murray, he said "*you have hit the correct solution of the Quebec group.*" The position of the Sillery beneath the Louzon and the want of conformity, explains many of the most knotty points connected with this group of strata in Canada," or words to that effect. I am sorry I did not think of obtaining a copy of that letter from Mr. Murray but I well remember his reading it for me. Of course I got no credit for my connection with the work. Now whatever may be the opinions entertained in Canada or the U. S., on this head, I am prepared at any time to prove my work in that section of this island, to anyone who will visit it with me. I think Prof. Hyatt, two years ago, bore out my work there. There were other parts of this island where it was not so easy to determine the position of the serpentines, and indeed where the evidences seemed to point to a different horizon. I suggested the possibility of there being two or even more zones of serpentinous strata, not confined to the same horizon, but Mr. Murray would not entertain that view at all. Of course it was a mere suggestion; I had no evidence to bear it out, but one thing is certain, were it the case, it would at once remove all cause for the conflicting views held with regard to their true position.

It is a great pity this island is not either part of the Dominion or United States, in which case its most interesting geological structure would be closely studied. I am convinced there is no place in North America where the Eozoic formations are better displayed, more abundantly supplied with organisms, and where the outcrops are so numerous and accessible. Now that some of your geologists are beginning to find out how interesting the country is, I hope we may be frequently honored with their visits.

I almost forgot that while writing of the primordial rocks I should mention that I did not include the great formation of at least 10,000 feet in thickness (Mr. Murray's Huronian) which lies beneath them here. Whether it should be included in the primordial or Taconic, I can not say, but certainly in Conception bay the latter rests uncon-

formably upon the Huronian in several places. There are but two fossils found in it so far, *Arenicolites spiralis* and *Aspedello terranovica.*[4]

Yours sincerely,

JAMES P. HOWLEY.

THE TERMINAL MORAINE NEAR LOUISVILLE. Having lived for more than seventeen years on the "backbone" of Long Island, N. Y. before coming to Louisville, Ky., I was naturally attracted by the clayey deposits of this region, so similar in character to the glacial deposits of Long Island.

I was aware that the line of the terminal moraine of the great continental ice-sheet was drawn farther to the north through central Indiana, but the more I studied the matter the more I became convinced that the glacier had something to do with the clay and cherty formations of Kentucky. This opinion has been confirmed by Profs. Newberry and Collett. Instead of a lobe of ice, however, flowing down a glacial river through central Indiana to the Ohio, as described by Prof. Collett, there is evidence that the whole eastern part of the state was covered by the great ice-sheet.

While the glacier seems to have taken a southeast trend, the streams under it flowed in a southwest direction. Crossing the Ohio river at Louisville these subglacial streams seem to ramify very much the same as those of Long Island. The limestone ridge east of Louisville is very much broken, especially toward the south. In places it entirely disappears, or exists only in little round isolated hummocks as it nears the knobs. Here a vast basin was formed which is now known as "the wetwoods." The present outlet of the Ohio, through the knobs, could not have been sufficient to carry off the great flood of waters, and so they became dammed up behind the Kentucky hills, or cut their way through forming them into the peculiar contour which they now present. If we follow up one of the old subglacial depressions as far as the knobs we find it connecting with a corresponding depression in the hills, showing that at one time there must have been some relation between them, although water alone could hardly have produced such results as are here presented. The summits of the highest knobs are not only worn into pot-holes, but there are well defined kettle-holes, and boulders of granite are often met with in the clay. It is true that these boulders are small and have the appearance of being water worn, and the floods may have reached the height of four or five hundred feet, but the writer has found boulders of sandstone and granite lying together several miles up the river from the knobs at the height of ninety feet above the present level of the stream. These certainly could not have been deposited by water unless the water ran up hill. The boulders referred to, lay exactly in the path of the glacier as it crossed the river from the New Albany, Ind. knobs.

[4] These two fossils are the oldest organic remains found in North America. They belong to the Infra-primordial fauna or Lower Taconic.—J. M.

It is well to be careful in coming to any definite conclusion in regard to these phenomena, but they are certainly worthy of scientific attention.

Long years of careful study of the drift formations have convinced the writer that the glacial area in America is more extensive than has been imagined, and that no well defined terminal moraine can *wall in* its extreme southern limits.

Striæ here and there may guide us in determining the general flow of the glacier, but they are not an infallible guide as to its extent, as it has been demonstrated that glaciers move over surfaces without eroding or leaving scratches of any kind; yet to maintain that none of these signs are produced by the motion of glaciers would be very absurd. It would be equally so to say that there were no terminal moraines because they cannot always be well defined. The "backbone" of Long Island is very much broken and disjointed, but it would hardly be just to say that it had no vertebral column at all. There are wide gaps to be filled in along the line of the terminal moraine of the great American continental ice-sheet, and prudent geologists will be careful in drawing the line until more of the facts are known in relation to glaciers, especially one so startling and confounding as that which covered more than half of the north American continent.

Louisville, Ky. JOHN BRYSON.

PERSONAL AND SCIENTIFIC NEWS.

ANOTHER BURNING GAS-WELL has recently been discovered near Albert Lea, Minnesota. A well was being drilled, and at the depth of 63 feet a copious flow of gas was encountered. All these Freeborn county gas wells are shallow, not exceeding 75 feet, and it appears in the light of the deep-well lately drilled at Freeborn through the Trenton to the St. Peter sandstone, and even to the Lower Magnesian limestone, not finding any increase in the supply, that the source of all of the gas thus far discovered in Freeborn county is in the drift or in the Cretaceous, with the greater probability in favor of the drift.

IN BORING FOR WATER on the farm of Mr. Charles Estle near Columbus Junction, Iowa, gas was encountered at a depth of about 120 feet. The well was bored in superficial deposits of sand and clay which have been laid down in post-glacial times by the Cedar River. The gas was almost odorless, and burned with a yellowish blue flame. The flame is reported to have been fifteen feet in length and three feet or more in diameter. After flowing for about twenty-four hours the supply suddenly ceased. Evidently the drill had reached a small reservoir of marsh gas which had been imprisoned under a capping of clay.

PROF. SETH E. MEEK OF COE COLLEGE, IOWA, contributes to the *Annals of the New York Academy of Sciences* an interest-

ing paper on the *Fishes of the Cayuga Lake Basin.* The list as given by Professor Meek embraces 21 families and 59 species including varieties; 26 species are enumerated as food fishes; 28 species are accounted valuable as food for other fishes; and 5 are of little or no economic value.

IT NEED ELICIT NO SURPRISE to find the wives of our leading geologists making a name and reputation for themselves in the domain of science. Mrs. Anita Newcomb McGee is well known as a successful student of sociology and Anthropology. Some months were spent last year in personally investigating the Iowa communities at Amana and Icara. Among the recent publications from the pen of Mrs. McGee are *Notes on American Communities,* and *Organization and Historical Sketch of the Women's Anthropological Society of America.*

PROFESSOR C. H. GORDON, OF KEOKUK, IOWA, has been contributing a series of interesting articles on geology to the local papers, and thus has demonstrated in a very practical way what the teachers of our public schools may do in the way of disseminating correct scientific information. Local interest in geology at Keokuk has recently been stimulated by the boring of one or two deep wells. As reported by Prof. Gordon the formations passed through are essentially the same as those penetrated by the deep well at Washington, Iowa and described in the GEOLOGIST, Vol. 1, No. 1, Jan. 1888. One point of difference of especial interest, however, is the presence of heavy beds of limestone below the St. Peter's sandstone. Prof. Gordon reports that the St. Peter's was passed through at a depth of 1,050 feet, below which point the drill penetrated a succession of limestones alternating with calcareous sandstones,and that at 1770 feet, the depth reached at the last report, the drill was still working in hard limestone.

It is possible that at Washington, Iowa, as suggested by the writer of the article referred to, the equivalent of the Lower Magnesian limestone had not been reached when operations were suspended.

THEODORE DWIGHT WOOLSEY, D.D., L.L.D., for years a commanding figure in the world's educational circles, died at his home in New Haven, July 1, 1889. President Woolsey is the name by which he has been most endeared and most widely known. From 1864 to 1871 he was president of Yale college; the burdens of college administration being voluntarily laid aside in consequence of advancing age. President Woolsey was the author of a number of books that immediately took and permamently held a high rank in their respective departments of inquiry and investigation. His best work was done in the domain of social and political science.

THAT EXCELLENT MONTHLY, *The American Naturalist* is for some unfortunate reason a little belated this year. Its March number reached its subscribers about the first of July.

THE PROPOSITION OF MAJOR POWELL, to construct large reservoirs in the Rocky mountain region for the storage of the surplus water of the Spring months has much to commend it. The water that simply runs to waste at a season of the year when it is not needed, could be drawn upon during the rainless months of summer and made to fertilize large areas of the neighboring plains that are now practically a desert. In view however, of the recent Johnstown disaster the scheme of storing large volumes of water in artificial lakes excites in many minds more or less distrust. There are no engineering difficulties in the way of constructing dams of adequate strength for all ordinary emergencies. The difficulties in the way of maintenance however are not easily met owing to the impossibility of knowing at all times where and in what way and to just what extent the structure is being weakened by the operation of natural and probably unlooked for causes. A slight earthquake or flood of unprecedented violence may without a moment's warning, precipitate the whole flood of pent up waters on the valley below. Such reservoirs might last for centuries, and yet it must be admitted that they are an ever present menace to life and property. A recent number of *Garden and Forest* raises the note of warning.

THE LEGISLATURE OF MISSOURI at its last session enacted a law authorizing a geological survey of the state. The law selects a commission of four distinguished gentlemen, from different parts of the state, including the Governor of the commonwealth, to initiate the survey, appoint its chief officer and select its headquarters. It particularly specifies that the survey shall not be connected with or controlled by any institution of learning. An appropriation of $10,000 a year for two years was made for use in carrying out its provisions. It is gratifying to know that the work so well begun by Shumard, Swallow and Broadhead is now likely to be carried on to its completion.

MR. WARREN UPHAM of the U. S. Geological Survey, will spend the summer in completing the work of tracing out the boundaries of the glacial lake whose ancient bed he discovered while at work upon the Minnesota survey and which he named lake Agassiz. He finds the lake-beach continuous and clearly marked. Its basin covers an area six hundred miles in length and from thirty to three hundred miles in width and now includes several lakes among which are Rainy lake and the Lake of the Woods.

DR. ALEXADER WINCHELL is engaged upon the study of the Cretaceous fossils preparatory to writing a monogram upon the subject for the U. S. Geological Survey.

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DOUGLASS HOUGHTON,

GEOLOGIST. LAKE SUPERIOR.

Original Portrait by Alvah Bradish. Copyright 1889, by A. Bradish.

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THE

AMERICAN GEOLOGIST

VOL. IV. SEPTEMBER, 1889. No. 3

DOUGLASS HOUGHTON.

BY ALEXANDER WINCHELL.

The fourth decade of the present century produced a body of geologic investigators whose brilliant achievements constitute them a galaxy in the firmament of American science. The preceding decade had given birth to Eaton and Dewey and Green, and the lustre of Maclure's name had not yet faded. To a large extent, their example and teaching were the conditions of the advent of the great workers of the fourth decade —Edward Hitchcock, Ebenezer Emmons, Henry D. and W. B. Rogers, William W. Mather, Lardner Vanuxem, James Hall and Douglass Houghton—workers whose labors illuminated still more brilliantly the fifth decade, and one of whom still lingers to set an example of fidelity to a host of younger compeers and aspirants in this ninth decade of the century. Of the distinguished workers of the fourth and fifth decades Douglass Houghton was youngest. His fellow-laborers indeed, considered him young—too young, almost, for the aspirations which animated him, and the independence which characterized his judgments. He was still young when his brilliant career was cut short—not too young to have left an impression on the science of the country, and to have determined a bias in the industries of his adopted State.

Douglass Houghton was the son of Judge Jacob Houghton[1] of Fredonia, New York. His mother was Mary Lydia Douglass, of New London, Conn., from whom he received his name. Judge Houghton had removed to Fredonia from Bolton, Mass., in 1812. His ancestors came to America about 1758. The American family is descended from an honorable English stock residing in Bolton, Lancaster, from the time of the conquest. The name was originally De Houton. The present head of the family is Sir Henry Bold Houghton, a member of Parliament.

The date of Douglass Houghton's birth was September 21, 1809. His early constitution was delicate, but his intelligence was bright, and his nature was sympathetic and sensitive. He was reared amid the influences of books and high ideals. He was destined for an education, in the hopes of both his parents. His father, though settled in the wilderness of Chautauqua county, was able to command the conditions which brought the realization of his hopes. The Fredonia academy was organized in 1824, and Douglass was among its earlier pupils. Though faithful to study during his academic career, tradition represents him as party to many of those pranks to which nature instigates so many of those whom she has chosen for distinction and influence. The boy who leads in pranks is father to the man who leads his State. Douglass, by the educational maxims of his time, was consigned to the usual routine of Latin drill; but by the bent and appointment of a forceful intelligence, he was destined to a life of scientific devotion.

This destination early revealed itself in many ways. Back of the orchard, a few rods from the residence, the Houghton boys made an excavation in the bank, and roofing it over, dedicated the simple structure to the uses of a laboratory and study. After some months, it became also, a powder factory—the requisite machinery and water power having been devised by the young Houghtons. One day an explosion occurred in

[1]The sources from which the present notice is drawn are a sketch by his co-laborer Bela Hubbard, in *Amer. Jour. Sci.*, II., v, 217-227, May, 1848; a memoir recently published by Prof. Alvah Bradish (8vo. 302pp., Detroit, 1889); personal communications from Mr. Hubbard who still resides in Detroit, and traditions preserved in the memory of surviving relatives and friends. Of Prof. Bradish's memoir I shall speak more particularly.

this mill. Douglass narrowly escaped total blindness. This accident was coincident, naturally, with a new trend in Douglass Houghton's scientific activity.

At a youthful age, Douglass entered the Van Rensselaer Institute at Troy, then under the charge of Prof. Amos Eaton. This destination was opportune. It suited the nature of the young man, and opened the way to the crowning of his hopes. Graduating as Bachelor of Arts in 1828, he waited but a few months to receive from Eaton the appointment of assistant professor in chemistry and natural history. Such was his standing that in 1830, he was selected by Eaton to deliver a course of lectures on chemistry, botany and geology in the distant and quaint old French town of Detroit. It is worthy of note that a course of scientific lectures had been provided for by the leading men of Detroit—Gen. Lewis Cass, Governor of the territory, Maj. John Biddle, Col. Henry Whiting, E. P. Hastings, Shubal Conant, Rev. Dr. Berry and others—let their names be perpetuated for an example to the leading Detroit gentlemen of the ninth decade of the century. Hon. Lucius Lyon, a delegate in Congress from the Territory, was to call on professor Eaton on this business. Though the youth of the the chosen lecturer dismayed the stately delegate, he soon discerned adequate maturity of thought, and the course of lectures became the resort of the *élite* of the town.

This was Houghton's introduction to the State of Michigan. It was in 1830, and Houghton had just attained his majority. He was destined now to settle in Detroit in the practice of medicine. He had studied under Dr. White at Fredonia, before his departure for Troy, and in 1831 he was admitted to practice by the Medical Society of Chautauqua county. In Detroit, his education, his talents and his affability gained him rapidly many friends whose devotion went with him during life.

A few months after his arrival in Detroit, he received the appointment of surgeon and botanist to the expedition for the discovery of the sources of the Mississippi, organized under the direction of Henry R. Schoolcraft. His report on the botany of the remote and wilderness regions passed over, displayed extensive acquaintance with the science, and constituted a permanent contribution to our knowledge of the flora of the

Northwest, for which he still stands credited in American Manuals.

From 1832 to 1836, he practiced as a physician and surgeon, never relaxing however, his pursuits in natural science. During the visitation of cholera in 1834, he performed many acts of heroism and noble charity, for which he is remembered to this day. In 1836 he matured the scheme for the Geological Survey of the state. To the promotion of the interests of this work he devoted the next nine years of his life. At this date geological surveys had been carried to completion in very few states or countries, but now an interest was arising which extended throughout the Northern States. It is worthy of note, however, that the lead was taken by North Carolina in 1824, and South Carolina in 1826. Massachusetts had furnished an example and a stimulus to other northern States since 1830. The survey of Tennessee had been organized in 1832, that of Maryland in 1834, of New Jersey and Virginia in 1835. Acts were passed in New York, Maine and Connecticut in 1836, and in Ohio, Indiana and Michigan.[2] in 1837. Before the decade was closed, surveys had been ordered in Kentucky, Rhode Island and the mineral lands of Iowa and Wisconsin. There was a wide and active awakening to the importance of that modern form of scientific and economic enterprise which is exhibited in public geological surveys.

An alert intelligence like Houghton's could not fail to enter into the spirit of the time, and there would be little difficulty in conceiving a practicable plan. To induce a population just emerged from a territorial condition to give their practical endorsement to such a plan, demanded gifts which were more than scientific. Only a born public leader could have carried such a scheme into effect. It must be remembered nevertheless, that for obvious reasons, the difficulty was less in those times than would be encountered to-day. Though the State was only a month old, Detroit, its capital, had been settled since 1701. In the missionary operations of the Jesuits, Detroit was long a central post, while in the wars with Indians, French and British, it was regarded as a strategic point. The military establishment was the nucleus of a spirit of intelligence, honor and respect for superior station and worth. Detroit was there-

[2]The bill was signed by Gov. Mason, Feb. 23, 1837. The State was declared a member of the Federal Union, Jan. 26, 1837.

fore already in advance of the average character of the west, or even of western towns. Those too, were days in which the leveling spirit of democracy had not destroyed the rightful influence of superior intelligence. The Legislature assembled at Detroit was predisposed to listen to the judgments of such men as Gen. Cass, Dr. Zina Pitcher, Henry N. Walker, Maj. Henry Whiting, Charles C. Trowbridge, Stevens T. Mason and Dr. Douglass Houghton. Still, nothing less than the tact, urbanity and captivating humor which distinguished Dr. Houghton, could even at that time, have secured an appropriation of $29,000 to be expended during a period of four years.[3] The financial crash which fell upon the country in 1838, was peculiarly distressing in Michigan, in consequence of the lavish scale of general internal improvements which the infant State adopted, and most of which were paralyzed during the years which followed. To sustain the heart of the State in a geological enterprise of such considerable magnitude was a greater achievement than to secure its original assent.

To the geological reader the sketch of the next nine years of Houghton's activity embraces the culminating interest of his biography. It seems appropriate, however, to reduce to a minimum the exposition of the scientific results of his labors, and to restrict the present notice to a history of the man and his personal relations.

Under provisions of the act passed in the beginning of 1837 Dr. Houghton occupied most of the season in investigations relating to the "salt lands" of the State, donated by Congress in 1836. Many salt springs had long been known. Houghton, from surface indications and general principles, argued that the source of supply was a deep-seated formation which might be reached by boring or by sinking of shafts in the vicinity of the salines. Accordingly, the Legislature of 1838 appropriated

[3]The total expended by the State for the survey during the four years, was $31,597. In 1841 the State made another appropriation of $6,219; in 1842, one of $3,703; in 1843, one of $2,020; in 1844, one of $2,535; in 1845, one of $1,832; making total appropriations for the Houghton survey, $52,000. But of this $4,171 remained unexpended. The present writer in June, 1886, by request, transmitted to Director J. W. Powell, for the use of the United States Geological Survey, a pretty full "History of the First Geological Survey of the State of Michigan," embracing memoirs of Dr. Houghton and others. It may here be added, that in November of the same year, he transmitted also a paper on "Public Geological Surveys in Michigan under the Direction of Professor Alexander Winchell."

$3,000 for such experiments, and Dr. Houghton located two wells—one near Grand Rapids and one on the Tittabawassee river. To these enterprises much attention was given, and in them many difficulties were encountered during two or three years, with an expenditure of $45,000 of special appropriations, but without attaining the results expected. The Tittabawassee well was carried down 139 feet and abandoned in 1842. The Grand Rapids well was sunken 876 feet, and abandoned in 1843. Had Dr. Houghton been in possession of modern facilities for boring, he would probably have achieved success in the Tittabawassee well, and salt manufacture would have been commenced in Michigan twenty years earlier than it was.

The Legislature of 1838 placed the survey on a broader basis, authorizing departments of zoölogy, botany and topography, as subordinate to geology. Besides the requisite attention to the salt enterprises just mentioned, Dr. Houghton, this season, made explorations along the shores of lakes Michigan and Huron, and in some limited portions of the interior and southern counties. One cannot peruse the report rendered in 1839, without receiving a vivid impression of Dr. Houghton's geological sagacity. Though he gives expression to certain inferences and suggestions which later studies have not justified, his obvious characteristic as a geologist is largeness of view and a tendency to grasp the geology of Michigan in its correlations with that of surrounding regions. He thinks the rocks of the northern part of the Peninsula "may be regarded as referable to the great Carboniferous group of the state—a position to which their fossil contents are amply sufficient to substantiate their claim."[4] Again, referring to the range of hills a little south of Thunder Bay river which "stretch in a southwesterly direction toward the head of lake Michigan," he says "they follow the line of bearing of the rock formation, and no doubt extend diagonally completely across the state, forming a portion of the summit of the more northern part of the Peninsula" (pp. 6-7.) "The ridges of limerock," in the vicinity of Little and

[4]Such an opinion cannot be considered a disparaging error, since the dividing line between the Carboniferous and the Devonian had not been clearly fixed in American geology. In his *First Annual Report* on the Fourth District of New York, James Hall spoke of the limestones of the Helderberg mountains as "Carboniferous or Mountain Limestone." (*Reports N. Y. Geol. Surv.*, 1837, pp. 290, 300.) A similar reference is made of that at Black Rock, etc. (p. 302, note, 307, 374.)

Grand Traverse bays "are without doubt, a continuation of the line of bearing of the great limestone formation of Wisconsin." On the whole, however, Dr. Houghton reveals in this first glance at the general geology of the Lower Peninsula the tact and sagacity of a skilled observer. This report is accompanied by those of the various assistants.

The report of observations made by Dr. Houghton in 1839, dated February 3, 1840, is devoted to the Northern Peninsula. This and that of the following year, dated February 1, 1841, are the two most important and original contributions made by Dr. Houghton to geological science. In these reports he describes the rocks of the Upper Peninsula under the following divisions: 1. Primary Rocks, 2. Trap Rocks, 3. Metamorphic Rocks, 4. Conglomerate, 5. Mixed Conglomerate and Sandstone, 6. Lower or red Sandrock and Shale, 7. Upper or Gray Sandstone, 8. Sandy Limerock. The Primary Rocks consist chiefly of granite, syenite and syenitic granite. The extended range of Trap Rocks flanking the Primary rocks on the north or northwest (relative positions being reversed on the north shore—hence, he says, proving the basin of the lake synclinal) are themselves flanked on the north by amygdaloids which in part, result from the intense alteration of sedimentary rocks next in order. From the masses of greenstones proceed dykes (so called) which intersect the newer formations in planes conformable with their bedding. The writer gives a careful and particular description of the true veins which intersect the dykes, the amygdaloid and the sedimentary rocks,[5] but, like the dykes, they comform to the bedding of the amygdaloid and the sandstone. These veins, he says contain native copper.[6]

The Metamorphic rocks consist of talcose, mica and clay slates, slaty hornblende rock and quartz rock. These are the rocks claimed by Emmons as representing the Taconic system in Michigan. To these must be added the argillites first reported as included in the "Lower Sandstone and Shales."

[5]Besides the descriptions embraced in these reports, Dr. Houghton presented a careful summary touching metalliferous veins, before the "Association of American Geologists" at Philadelphia, in 1841. (See Transactions, pp. 35-38. See also, Amer. Jour. Sci.

[6]A statement which aroused a discussion in the meeting of 1843. *Amer. Jour. Sci.* XLV. p. 160, 1843.) A report was made on the subject in 1844 (*Amer. Jour. Sci.* XLVII, 132, 1844).

The Conglomerate, No. 4, and the Mixed Conglomerate and Sandstone No. 5. (constituting the Keweenawan system of Chamberlin and Irving) are made up of volcanic ejections—the sandstone layers having the same greenstone composition as the conglomerates, but being finer and evidently deposited as sediments in shallow water. The "Lower or Red Sandrock and Shale," No. 6, at first supposed to represent the "Old Red Sandstone,"[7] then in 1843 the "New Red,"[8] was subsequently pronounced the equivalent of the Potsdam sandstone of New York.[9]

In his brief report dated January 25, 1842, Dr. Houghton says the survey has made progress, though the unavailability of funds has been a hindrance. He speaks of duties assigned relative to the boundary line between Michigan and Wisconsin. He makes mention of other detailed work in exploration of the Porcupine mountains, and the rivers in the western part of the Upper Peninsula. Though the field-work on the scale originally contemplated, is now nearly complete, a large amount of laboratory and office work remains, for which he asks and receives a small appropriation. In this work the year 1842 was occupied, as he informs us in the very brief report dated January 3, 1843. This was his sixth annual report. In his seventh, dated February 15, 1844, he simply states that work on the final report is making some progress, but slow. He speaks of progress made on the county maps, and pathetically asks an advance of $1,000 or $1,500, to be reimbursed from the sale of the maps, when completed. This is his last report to the State. Though the office of state geologist was not abolished, no State report is found for the eighth and ninth years of his incumbency.

In the meantime, however, Dr. Houghton, despairing of the ability of the State to complete the work, meditated a connection between the linear and geological surveys of the Upper Peninsula. His plan was fully set forth in a paper read before the Association of American Geologists in Washington, in

[7] In the report of 1838, he says "The Old Red Sandstone in the vicinity of the Porcupine Mountains has been shattered similarly to the limestone of Mackinac island."

[8] *Trans. Assoc. Amer. Geol.*, 1843; *Amer. Jour. Sci.* XLV, 160.

[9] This view was embodied in his notes of 1845, reported on by Bela Hubbard. See Jacob Houghton's *Mineral Region of Lake Superior*, 1846 p. 118.

1844.[10] The advantages of such a combination were at once comprehended, and the project was warmly endorsed, and a committee appointed to "memorialize the proper department of the Government." The land commissioner, however, fearing the ordinary surveyors would not possess sufficient geological information, hesitated, until Dr. Houghton himself offered to take the contract. This was signed June 25, 1844, and the remainder of that season and the season of 1845 were occupied in completing preparations and carrying on the work. His contract with the surveyor general was nearly completed, when the lamentable event occurred which put an end to his zealous and useful activity in the development of the natural resources of his adopted State.

Dr. Houghton's death occurred by drowning, October 13, 1845, on the west shore of Keweenaw point, not far from Eagle river. He was returning in an open boat, with four men, from a trip made to provision one of his parties. Overtaken by a severe snow-storm with high wind, about nine 'oclock in the evening, the boat was thrown endwise by the waves, and dashed on the rocks. Doctor Houghton, with two of his voyageurs, was lost. His remains were recovered in the spring of 1846, and interred in Elmwood cemetery, Detroit. The place is marked by a monument erected by Mrs. Houghton.

It would not be proper to extend this notice; though it would be interesting and edifying to contemplate an analysis of Dr. Houghton's character, and seek to discover the elements of that power by which he commanded the respect, and even the admiration of all who made his acquaintance. This, however, is the less necessary, as his life and character have been so well portrayed by a surviving friend, professor Alvah Bradish,[11] an artist of wide reputation, an appreciator of science, and a member of various learned societies. Mr. Bradish for many years, was Emeritus incumbent of the Chair of Fine Arts in the University of Michigan, and for several years delivered lectures. In this volume the biographical sketch of Houghton occupies 75 pages. It is followed by brief sketches of several

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[10] *Amer. Jour. Sci.* vol. xlvii, 1844, p. 115.

[11] *Memoir of Douglass Houghton, first state geologist of Michigan. With an appendix containing reports and abstracts of the first geological survey, and a chronological statement of the progress of geological exploration in Michigan.* By Alvah Bradish, A. M., Detroit: Raynor & Taylor, 1889, 8vo, 302 pp.

of Houghton's contemporaries and friends, appreciative notices, details of the final catastrophe, an account of the Houghton portrait, a proposed monument, a memorial window at Marquette, and various memoranda and notes. A selection from Dr. Houghton's letters occupies 20 pages. The Houghton portrait, painted by professor Bradish, hangs in the capitol at Lansing. As a portrait it is said to be faithful and true to life. It represents the geologist as standing on the rocky shore of lake Superior. His dress is that of an out-door explorer—a loose summer coat, without vest, with leather suspenders, trousers of a lighter color, and high-top boots. He is resting and meditative. One arm is extended and rests on his hammer. The other holds his crushed and well remembered hat. A cliff of lake Superior sandstone rises in the background, and in the distance opens "The Portal," which constitutes one of the features of the "Pictured Rocks." A photo-engraved copy of this painting forms the frontispiece of the memoir, and an impression of it accompanies the present sketch.

With the geologist, another feature of the "memoir" will secure a cordial welcome, and that is the reproduction in the appendix, in abstract or in full, of all Dr. Houghton's reports, occupying 160 pages. As these reports have long been out of print, at the same time that they have been in very great request—the demand seeming to increase with lapse of time—these reproductions will be a boon to all geological investigators. They embody abstracts of the reports of Dr. Houghton's assistants. The fourth annual report, dated February 1, 1841, (89 pages) the most important of all, and containing the most matured results, is reprinted in full. The accompanying report of Bela Hubbard, (34 pages) the most important one made on the Lower Peninsula, is also reproduced, and here includes a colored section prepared at the time, but not engraved. The report also of S. W. Higgins, topographer, (26 pages) is fully reprinted

Dr. Houghton died at the age of 36. His brief career was one of intense intellectual activity. He was a leader among men. His life opened with brilliant promise, and was adorned by many honorable successes achieved. Only an act prompted by an excess of enthusiasm and the virtue of personal daring,

gave opportunity for the elements with which he had so often toyed, to blot his name, too early, from the list of America's most distinguished devotees of science.

HOW IS THE CAMBRIAN DIVIDED?---A PLEA FOR THE CLASSIFICATION OF SALTER & HICKS.

BY G. F. MATTHEW.

A new classification of the Cambrian system has lately been proposed by Mr. C. D. Walcott, the well known palæontologist of the United States Geological Survey and has received the assent of Prof. Chas. Lapworth. The most prominent feature of this classification is the basal position given to the Olenellus fauna which no doubt is in accordance with facts. Another point in this classification is the placing of the rocks containing the Paradoxides fauna as Middle Cambrian; with this the knowledge at present before the writer does not seem to agree. A while ago it seemed as though the Cambrian system was divided palæontologically into three sections, the Paradoxides beds, the Lingula flags and the Tremadoc or Ceratopyge beds, which would thus be the Lower, Middle and Upper Cambrian. But this "Upper" Cambrian was not only weak in bulk of measures, but in the genera it contained it exhibited a strong palæontological affinity to the Ordovician forms, so strong, indeed that by many European geologists it was classed as a part of the "Lower Silurian" system.

The discovery by Mr. Walcott of many of these so-called Ordovician forms, low down in the Cambrian strata of the Rocky mountain region, shows that a different interpretation may now be given to these forms, for they do not by their presence exclude the Ceratopyge or Tremadoc beds from the Cambrian. Nevertheless, under the classification proposed by Messrs. Salter and Hicks some twenty years ago, the Cambrian is divided into two great divisions only. The purpose of the present article is to review some of the evidence touching the faunas and the sedimentation of this system, and to compare the proposed division with that presented by Messrs. Salter and Hicks.

Late discoveries in America and Europe and especially the enlargement of the fauna with Olenellus and the discovery, or rather the determination of its proper place in the Cambrian

succession, has lead to this proposal for a new allotment of the parts of the Cambrian system.

If the object in view were merely the arrangement of the members of this system which may occur in any particular country, the sedimentation, or division into series, in that country could be utilized for the purpose, but as the object is a classification that will apply generally, other criteria must be sought. Among those which have been used are the succession of the several faunas and the relationship of the genera in each; and the comparative bulk of measures in the several parts of the system. These form the basis of the following remarks.

The Cambrian rocks as originally described by Prof. Sedgwick no doubt contained the Ordovician or Lower Silurian as well as the strata to which the name has since been restricted. These (the Lingula flags, etc.) were also claimed by Sir R. Murchison as a part of his Silurian system. In later times the conflicting claims of these discoverers have been compromised by assigning to each his own special domain, and erecting the disputed territory into a separate system, the Ordovician.

The development of the Cambrian system from its original basis in the Lingula flags, etc., received a great impulse from the discoveries of Dr. Henry Hicks and the late Mr. J. W. Salter in Wales; and especially in the finding of the Menevian fauna in South Wales, by Dr. Hicks.

In the process of elaborating the Cambrian faunas, the first step was the discrimination of the two faunas in the Lingula flags in 1853.

1865. In this year Messrs. Salter & Hicks made known the Menevian fauna, and showed the position of the Paradoxides beds in Britain.

1866. In this year the Tremadoc fauna was distinguished in South Wales, and fully confirmed in 1872.

1869. In 1869 Messrs. Hicks and Harkness described the great series of red, green and grey slates below the Menevian in South Wales, and showed the existence of a fauna older than that of the Paradoxides beds but with no trilobites.

Subsequently Dr. Hicks elaborated the Cambrian system into seven groups, but showing only four trilobite faunas, the first

or oldest not having been found by him in Britian. The groups of sediments containing these faunas he classified as follows:

Lower Cambrian. Three groups.—Caerfai, Solva and Menevian.

Upper Cambrian. Four groups.—Maentwrog, Ffestiniog, Dolgelly and Tremadoc.

It may be well to inquire what there is to support this classification of the Cambrian system, before adopting a new one.

Two principal criteria for determining a question of this kind would be the facies and succession of the faunas and the bulk of the measures. In applying these tests, we turn our attention first to Scandinavia, for in no other part of the world is there known such a clear, continuous and complete succession of Cambrian faunas as in that country.

Connection etc., of the Cambrian faunas.

Of the several classes of organisms in these faunas, the trilobites may be taken, as the group which will best show the relationship subsisting between the several faunas, for they are the most varied, and were more sensitive to the changing conditions of environment than the others.

In Brögger's admirable work on the Stages 2 and 3 of the Palæozoic rocks of Norway, a table is given which shows the succession and range of the species in the Cambrian faunas of that country. Then as regards the neighboring kingdom of Sweden, Dr. G. Lindström's list (1888) of the fossil faunas of the Cambrian and Lower Silurian rocks is complete for the several zones of the Cambrian in that country. Combining the genera from these sources a full representation of Cambrian life in Scandinavia is obtained, so far as relates to the genera of the trilobites.

The first or oldest fauna presents the following genera:

OLENELLUS (=MESONACIS) **Arionellus* (=*Agraulos.*)

**Ellipsocephalus.* **Agnostus.*

Of these genera one is peculiar and three (marked by an asterisk) pass to the next fauna.

In the second fauna are the genera.

**Harpides* *Anomocare.*

PARADOXIDES (including *Centropleura*)

Elliposcephalus *Dolichometopus*

**Liostracus* (includes *Ptychoparia.*)

Aneuacanthus (c.f. *Centropleura?*)

Conocoryphe. Corynexochus.
Elyx(=*Ctenocephalus.*) Microdiscus.
Solenopleura *Agnostus.
Arionellus, (=Agraulos.)

Here are fourteen genera of which three are found at higher horizons in the Cambrian system. Under *Liostracus* the Swedish palæontologists include *Ptychoparia* which with *Agnostus* has a wide range in the Cambrian system, so that with the exception of these genera the break is almost complete, between this fauna and that which follows. *Conocoryphe* as understood in Sweden does not extend beyond this fauna.

The third fauna contains the following genera:

Liostracus? *Leptoplastus.*
OLENUS.† *Eurycare* (s.gen. of *Leptoplastus*†)
Parabolina(s.gen.of *Olenus*†). **Agnostus.*

Here all the genera and subgenera are peculiar to this fauna except the ubiquitous Agnostus, and Liostracus?

But the connection with the next fauna is closer than appears from the names, as some of the genera are closely related to those of the succeeding fauna. *Eurycare* especially is intermediate between *Leptoplastus* and *Ctenopyge*..

The fourth fauna has the following genera:

**Cyclognathus* (subgen. of *Peltura*†)
Ctenopyge (s. gen. of *Leptoplastus.*†)
PELTURA. *Sphærophthalmus*, (s. gen of Leptoplastus.†)
Protopeltura, (sub. gen. of Peltura.†)

Boeckia (sub gen. of *Leptoplastus.*)
Acerocare (sub gen. of Peltura.†)
**Agnostus.*

Cyclognathus is found in a fauna above, but *Peltura* and *Ctenopyge*, with its related forms, especially mark this horizon.

The fifth fauna, which has a strong Ordovician facies, exhibits the following genera:

Cheirurus: *Nileus.*
Pliomera. *Symphysurus* (s. gen. of Nileus.†)
°*Harpides.* *Niobe.*
Remopleurides. °*Holometopus.*
°*Triarthrus.* *Conophrys.*

† See Brögger's Etagen 2 und 3.

°DICELLOCEPHALUS.
°CERATOPYGE.
°*Euloma.*
Megalaspis.
°*Parabolinella* (s. gen. of Olenus.†)
Amphion.
Ampyx.
°Agnostus.

Among these eighteen genera there are only about eight (marked by "°") which by their aspect recall the European types of the Cambrian trilobites, and probably for this reason the Swedish palæontologists regard this fauna as belonging to the Lower Silurian. But it evidently corresponds to the Tremadoc fauna, which by English palæontologists is reckoned to the Cambrian; and late discoveries in America show that Nileus, Niobe, &c., also are truly Cambrian.

In Wales, which has given its name to the Cambrian system, the succession of the faunas, their unity and their relative importance are much the same as in Sweden and Norway, but these features are obscured by the use of different names for some of the genera.

Mr. Robert Etheridge's catalogues in the Geology of North Wales are the basis for the comparisons made here. In them the genus *Conocoryphe* (as used by Mr. Salter) is made to serve for a number of Scandinavian and other genera. The figures of many of the species in this work are very imperfect, but for the purposes of this comparison the species in *Conocoryphe* may be distributed to *Conocoryphe*, *Ctenocephalus*, *Liostracus*, *Ptychoparia*, *Solenopleura*, *Euloma*, *Parobolina*, *Parabolinella* (?) *Conocephalites* and *Dicellocephalus*.

In Wales the first fauna has produced no trilobites unless *Conocoryphe viola* belongs here. The second Cambrian fauna has a full representation as follows:

PARADOXIDES.
Plutonia (sub gen. of *Paradoxides.*)
Anopolinus.
Solenopleura.
**Liostracus* (or *Ptychoparia*)
Holocephalina.
Arionellus (=*Agraulos.*)
Ctenocephalus.
Carausia.
Conocoryphe.
Erinnys (c.f.) *Harpides.*
Microdiscus.
**Agnostus.*

Here there are twelve genera of which two only extend upward to higher horizons.

† See Brögger Etagen 2 und 3.

The third fauna (Lower Lingula flags) has the following genera:

Olenus.	**Euloma*.
**Parabolina*.	**Agnostus*.

Of these three extend upward to the higher zone, leaving only Olenus as peculiar to this fauna.

In the fourth fauna (Dolgelly group) are the following genera:

**Euloma*.	Peltura.
**Parabolina*.	*Sphærophthalmus*.
**Parabolinella*. (?)	*Ctenopyge*.
**Conocephalites*.	**Agnostus*.

Five of these genera extend upward into the next zone. The *Conocephalites* have been called *Dicellocephali*, but they are not the typical forms with spined pygidium, which occur higher; they are related to *Conocephalites* (sens. strict) and *Conocephalina*,† which has short spines found by Brögger in the Paradoxides zone. The genus is not reported from the equivalent beds in Sweden, where the genera of the second column held possession, but it is found in the fauna of Hof in Bavaria.

The fifth Cambrian fauna (Tremadoc group) exhibits the following genera.

Psilocephalus.	°*Euloma*.
Asaphus.	°*Parabolina* (?)
Cheirurus.	°*Parabolinella* (?)
°*Angelina*.	°*Dicellocephalus*.
Nesuretus.	*Conophrys*.
Niobe.	*Ampyx*.
Ogygia.	°*Agnostus*.
Dionide.	

In this assemblage of fourteen genera only six represent "Cambrian forms" of trilobites, but in the first column are a number of genera which, once thought to have appeared first at this period, are now found to be present in the West of America by representative forms at a lower horizon. Hence these, although hitherto regarded as Ordovician, as already remarked, are essentially Cambrian types.

It will be observed that in the Welsh area the four Cambrian faunas, which have trilobites, show a correspondence of genera

†Om paradoxidesskifrene ved Krekling.

with those of Scandinavia, and here as there, exhibit a very decided palæontological break at the summit of the paradoxides beds. Hence Dr. Hicks was justified in dividing the Cambrian groups of strata into Upper and Lower, accordingly as they were above or below this horizon.

Having seen how the Cambrian faunas are related to each other in Europe, we may now examine their succession in the eastern half of North America.

To Mr. C. D. Walcott is due the credit of having determined the relation of the Olenellus fauna in this region to the rest of the Cambrian system.

The clearest succession of the lower members carrying unmistakable forms of this fauna is that which he has lately examined in Newfoundland. Combining the genera found there with those of the Champlain and Hudson valleys we find the following.

OLENELLUS.	**Zacanthoides.*
MESONACIS.	**Olenoides.*
**Paradoxides* (Shaler)	*Bathynotus.*
Avalonia (n. gen. not yet described.)	
**Ptychoparia.*	**Protypus.*
**Agraulos.*	**Microdiscus.*
**Solenopleura.*	**Agnostus.*

Of these thirteen genera it will be observed that two-thirds pass to the Paradoxides beds, and of the remainder, *Avalonia* is not described, and *Mesonacis* is by Scandinavian palæontologists regarded as a subgenus of *Olenellus.* There is thus a much closer connection between this fauna and that which follows it, than there is between the latter and the faunas of the Upper Cambrian. Moreover the embryonic and larval stages of Paradoxides and Olenellus show that the genera are closely related.

We have very little knowledge as yet of the way in which the Paradoxides fauna was related to that which follows it, since both in Newfoundland and Acadia the next zone has yielded very scanty remains of trilobites. Perhaps the Mt. Stevens section where the genus paradoxides has been found† will yield the required information. In Newfoundland Mr. Walcott has found *Olenus*, and in the St. John area (Aca-

† See this journal vol. III, No. 1. (Jan. '89.)

dia) *Leptoplastus* occurs. In the latter area also the fourth Cambrian fauna has been found, being indicated by the presence of *Ctenopyge flagillifor*, *C. spectabilis* and *Orthis lenticularis*.

A fuller presentation of Upper Cambrian forms is that which is found in the Mississippi valley in the states of Wisconsin and Iowa, where there is a succession of 600 feet of sandstones whose fauna has been described and figured by Prof. Jas. Hall. He divides this series into three parts, the lowest of which contains forms similar to those at the base of the Olenus zone in Europe.

In the middle division which is most prolific of the remains of trilobites, are species which may be compared to those of the genera *Olenus*, *Parabolina*, *Leptoplastus*, *Euloma* and *Conocephalites*. Dr. Dames compares others to *Anomocare*. It is only in the highest Potsdam division and in the beds above it according to Prof. Hall that the typical Dicollocephali appear, and these in Europe are found in the Tremadoc or fifth Cambrian fanua. *Triarthrella* occurring in Wisconsin with these Dicellocephali is compared by Brögger to *Cyclognothus*, a genus of the fourth fauna and of the base of the Ordovician. The whole series of 600 feet in Wisconsin seems to belong to the Upper Cambrian. But the phase of the fourth Cambrian fauna represented in Europe and Acadia by *Ctenopyge* and its allies is absent, probably from the want of favorable habitat.

Comparative bulk of measures holding the faunas.

The relative age and position of the Paradoxides beds in the Cambrian system may be shown by the bulk of the measures in the different parts of the system. With our present knowledge this can be only imperfectly done, but the following is a comparison of the mass of deposits in three different countries. When the system has been more carefully studied in different parts of the world a more exact proportion in the sedimentation will be had.

In Norway the Cambrian system has the following thickness.*

		Ratio.
Stage 3*a*=Tremadoc or Ceratopyge fauna	45 feet	1.2
" 2*d-e*=Dolgelly or Peltura fauna	40 "	1.0
" 2*a-c*=Lower Lingula flags, Olenus fauna	110 "	3.2

* Die Silurischen Etagen 2 und 3.

"	1c-d=Menevian and Solva, Paradoxides fauna,	80 "	.... 2.3
"	1a-b=Harlech (?) or Olenellus fauna.......	. 80 "	.... 2.3
		355 feet.	10.0

In Wales there are the following groups of Cambrian strata:

			Ratio.
Upper Cambrian.	Tremadoc	1000 feet,	1.
	Dolgelly	600 "	.5
	Ffestiniog	2000 "	4.5
	Maentwrog	2500 "	
Lower Cambrian.	Menevian	700 "	2.5
	Solva	1800 "	
	Caerfai	1500 "	1.5
		10,100	10.0

In Acadia the Cambrian sediments are intermediate in thickness between those of Wales and Norway. The average of two sections in the city of St. John gives the following proportions:

		Ratio.
Division 3=Dolgelly (and Tremadoc)..........	600 feet	.... 2.5
" 2=Ffestiniog and Maentwrog.........	1050 "	..... 4.0
" 1=Menevian and Solva...............	350 "	.... 1.5
Series A =Caerfai (?).......................	500 "	.... 2.0
	2500	10.0

In Newfoundland Mr. Walcott has found the Olenus beds to be about 600 feet thick and the Paradoxides beds 370† feet, which agrees nearly with the thickness of these portions of the Cambrian system at St. John (New Brunswick).

The Olenus fauna is found in Newfoundland, but apparently Mr. Walcott has not discovered there the fourth fauna (Peltura) or the fifth fauna. We therefore are still confined to the three countries of Scandinavia, Wales and Acadia as giving the most complete presentation of the sedimentation and life of the Cambrian period. Combining the ratios for these three countries we get the following result.

		Norway.	*Wales.*	*Acadia.*	*General Ratio.*	
Fifth fauna.....	Stage 3a	1.2	1.	1.*	1.1	6. Upper Cambrian.
Fourth "	" 2d-e	1.0	.5	1.5	1.0	
Third "	" 2a-c	3.2	4.5	4.	3.9	
Second "	" 1c-d	2.3	2.5	1.5	2.1	4. Lower Cambrian.
First "	" 1a-b	2.3	1.5	2.	1.9	
		10.0	10.0	10.0	10.0	

* The general average is taken for this portion.

These facts do not favor the separation of the Paradoxides beds from the Lower Cambrian, or their erection into a separate division as Middle Cambrian. If there is to be a Middle Cambrian it would rather seem that the Olenus fauna holds this position. But as has been shown the faunal relationship of the Olenus beds to those which follow them forbids their separation, just as in the Lower Cambrian a similarity in the forms correspondingly connects the Olenellus with the Paradoxides fauna.

THE MISSOURI RIVER.

BY G. C. BROADHEAD.

There remain certain features pertaining to the physical geography and geology of the Missouri not fully understood. Such I will briefly discuss, chiefly from my own observations which have been taken at the head of the main stream, at the Three Forks, Benton and Bismark, and extended from Sioux City to the mouth, the lower part having been studied both by land and water.

The valley drained by the Missouri may be divided into three areas which differ geologically and topographically, viz.: 1st. The upper or mountain district; 2nd. The plains; 3d. The lower valley region; or 1st. The mountain and igneous or volcanic; 2d. The plains, or Tertiary and Mesozoic; 3d. The lower valley or Palæozic.

The Missouri is formed by the junction of the Jefferson, Madison and Gallatin at Gallatin City, Montana, lat. 45° 52′ N., long. 113° 30′ W. of Greenwich. These three streams take their rise amid the snowy peaks of the Rocky mountains and for 400 miles below the forks the water is clear and beautiful. The latest revised estimates give 2,766 miles from the mouth to the Three Forks. Early trappers and voyageurs considered the Missouri as 4,000 miles long. The Three Forks are each from 200 to 300 miles long and bold and rapid. The Madison takes its rise in the southwest part of the Yellowstone park, being formed by the junction of the two forks of the Firehole river. The east fork is about ten miles long, the south fork about 25, traversing in its course the homes of the grandest geysers of the world and deriving its chief supply of water from them. The mountains adjacent are of later Tertiary volcanic. Just east of this and but a few miles away the Yel-

lowstone takes its rise and passes through that wonderful and beautiful sheet of water, Yellowstone lake, 7735 feet above the sea, thence through rhyolitic cañons and over grandly beautiful falls for over 200 miles, at last seeking the plains; and it at length unites with the Missouri. The lower half of the Yellowstone passing through the "Bad lands" partakes of the general character of the Missouri.

Of the Missouri, 2,518 miles are navigable by steamboats from its mouth to Ft. Benton. It can be navigated to the foot of the falls, 25 miles above Ft. Benton, or 2,543 miles from the mouth. The entire stream includes 2,350 miles of sandy river and 416 miles of rocky river. The general character of its channel, current, banks, and width and its variable character of channel, current, banks and width do not differ from its mouth to the Yellowstone, 2,000 miles. It is decidedly muddy to the mouth of Milk river, 80 miles further up and not entirely clear until we pass the mouth of Marias river, 20 miles below Ft. Benton. It really gradually changes its character from the mouth of the Mussel-Shell to Milk river, where it cannot be distinguished in its general character from the river far below.

The banks in many places, to within 200 miles of Ft. Benton, resemble those of the lower river, and below that point, Cottonwood trees are often seen falling in and the banks cave as they do on the Lower river. Bird's Rapids, 100 miles below Ft. Benton, is practically the last rapid. Below this to Bismark are numerous sandbars and as the river falls after the summer rise the channel at first is considerably spread out and is unreliable.

Carroll is 2,356 miles above the mouth, and from that place, for 1,300 miles down stream, the river seems annually to be subject to changes by channel shifting and banks and trees falling in, and in this distance there are no solid rock ledges available.

Between Ft. Benton and Bird's Rapids, or for 100 miles there are 24 serious rapids.

The river bed is considered rocky only from its head to Carroll.

The Great falls, with intervening rapids and cataracts, extend for 15 miles up stream, or from the mouth of Belt creek to the head of the rapids below the mouth of Sun river, and

include a total descent of 574 feet, including Black Eagle falls, 26 feet, Rainbow falls, 20 feet, and Great falls, 90 feet.

Above the falls, the stream is generally too rapid and curves too sharply for steamboat navigation, but from personal observation, I think that a channel depth of three feet can be secured on most of the rapids to Three Forks, certainly to "Gates of the Mountains." On this part of the stream there are practically no sandbars but the shoals are chiefly obstructed by rocks of various sizes mingled with some sand. Below Atlantic cañon is Half-Breed rapids, one and a half miles long, and our time through it in a skiff was 4 minutes. Other sharp bends are Whirlpool rapids and Mandible point, –the latter just below "The Gates of the Mountains" where the stream flowing in one direction for 3 miles makes a detour parallel with its former course for 3 miles, separated only by a narrow ridge. There are estimated to be 33 rapids from Three Forks to "Long Pool." The Long pool is a quiet reach of 40 miles from Ulidia to the Great falls.

The upper portion of the river is flanked chiefly by rocky cliffs, generally approaching near the water on one side, and retreating a little on the other, with grassy front. At "Gates of the Mountains" are cliffs 2,000 to 3,000 feet high for four miles on each side. At this place is a prominent point called "Bear Tooth" mountain, 2,500 feet high, a prominent feature for 20 to 40 miles away. Other prominent points on the upper river are Red Rock cañon, 1,000 feet, Black Rock 800, El Dorado 800 and Helena 800 feet high, Copper rock 1,000 feet, Atlantic Cannon 700 to 900 feet. For 50 miles below "Gates of the Mountains" the scenery is grand, the mountains high and clothed with scattering pines, the water clear, and the rocks weathered into many curious and striking forms as "Copper rock," DeLacy's point, Eddy rock 1,200 feet high at entrance of Atlantic cañon, Black Rock, Robber's castle, "Man and Woman," and Big rock 1,100 feet high. The area drained by the Three Forks is estimated to be 12,500 square miles and the rise at their junction never over 6 feet above low water mark. Ice gorges do cause a local rise a little higher and the snow melting in May causes the discharge to be 4 times the normal amount, and at the lowest 1–5 less. Roberts estimated the discharge to be:

Jefferson River	3,778.33	cubic feet per second.	
Madison "	2,670	"	"
Gallatin "	2,073.33	"	"
Total	8,521.66	feet per second.	

The area of the Missouri drainage, above the mouth of the Yellowstone is 93,000 square miles.

That of the Yellowstone is 78,700 square miles, and both united 172,000 square miles. The entire river drains 510,000 square miles. The mouth of the Yellowstone is 2,000 miles above the mouth of the Missouri.

A striking feature of the Missouri river is its remarkable impetuosity for so great a distance; also the continual whirling agitation of its waters, and the large amount of earthy material held in suspension. Its character seems different from other streams, and it imparts its own character to the Mississippi river below their junction. Its range of surface below Sioux City (781 miles from the mouth) varies from 16 to 20 feet. The amount of water discharged is subject to variation. The observations of Col. C. R. Suter, at St. Charles, in 1879, showed a variation from 26,446 to 298,537 cubic feet per second for a range of 17½ feet on the gauge, or a low-water volume of 1–11 that of high water, and an ordinary range of gauge would give volumes of 15,000 and 430,000 per second for low and high water, or low water volume 1–28 of high water volume. At Sioux City the variation is about the same.

The main valley consists of a great rock trough 1½ to 17 miles wide. From Sioux City down, the bed at one time seems to have been filled with glacial drift, subsequently in part cleaned out. Boulders are found resting on the bed rock, sometimes cemented together with gravel and sand. These were found in excavating bridge foundations both at St. Charles and at St. Joseph. Below St. Joseph the valley averages 2½ miles in width; above to Sioux City it is wider.

The general depth to the rock-bed of the lower river, varies from 70 to over 100 feet. Most bridge piers have reached solid rock. The velocity at St. Joseph at ordinary spring floods is 3 8–10 miles per hour, at low water 2 6–10. At low water the channel at St. Joseph is 400 to 500 feet wide and 15 to 30 feet deep, and the difference between high and low water is 23 feet; width at floods 1,420 feet. Rock is 43 to 48 feet below low water. There is a deposit of 40 feet resting on solid rock consist-

ing of boulders, pebbles, coarse and fine sand, the coarser below. The velocity at St. Joseph at low-water is 2 to 3 miles per hour, and in floods as much as 10.

Bank erosion is constantly going on in the lower river; whole farms have been washed away in less than a decade of years, and the channel shifts from side to side; what is destroyed on one side may go to form land upon the other side. The general slope of the river averages 0.88′ to the mile, both at high and low water (Suter).

The actual navigable depth varies from 3 feet at low to 9 at high water. Col. Suter's observation at St. Charles gave, for sediment carried past for 1879, 5,508,229,008 cubic feet, the water discharge for the same time 2,335,143,946,400; and on July 1st, 1879, the amount of sediment transported would cover one square mile 4 feet, and during the entire year 197.58 feet deep; this not including that directly upon the bottom which if counted would increase the amount, even might double it. The approximate width from Sioux City to the mouth of the Platte is 820 feet. From the mouth of the Platte to Kaw river is 960 feet. From the mouth of the Kaw to Gasconade it is 1,160 feet. From Gasconade to the mouth of the River it is 1,240 feet (Suter). Low water for the same would be (Suter) 650 feet, 820 feet, 1,020 feet and 1,100 feet.

While the Mississippi valley including the Ohio, the upper Mississippi and the Missouri valley as far up as near Sioux City was dry land during Palæozic times, and during the succeeding Mesozoic and Tertiary periods, there lay just west a low ridge (or scarcely a ridge being mainly an approximate line whence strata dipped rapidly west) passing northward through central Kansas into eastern Nebraska and northwardly. This ridge or very flat anticlinal prevented the waters of the Laramie seas from flowing eastwardly and formed the eastern margin of the Laramie brackish water lakes, which during a long period of time gradually and slowly settled sufficiently to receive the lignitic coals and other succeeding beds of clay and silt. After the close of the Laramie and during later Tertiary times, the fractures incidental to the volcanic outflows in the Rocky mountain and Columbia river regions, formed the channels for the Columbia, the upper Missouri, Yellowstone and other Rocky mountain streams.

The lower Missouri already had its existence. IT DATES ITS

EXISTENCE *to the period of the* OZARK UPLIFT, as shown in my article previously published.[1] That article pertained only to the Ozarks and adjacent country, and although not definitely designated I intended only to convey the idea of the age of the lower Missouri, and not of the upper portion. The upper river was not then considered.

The age of the lower Missouri, at least from Omaha down, is contemporaneous with that of the Mississippi from its head to the mouth of the Ohio. The Monoclinal along the eastern border of the Ozarks is either directly in the channel of the Mississippi, or in hills near by, as shown by eastern dipping of rocks, and strikes of low anticlinals passing eastwardly. The monoclinal along the northern border of the Ozarks is also very near the channel of the Missouri river, or in the hills adjacent, as proven by examination at numerous places near the river where the strata dip strongly to the North, and also by the several strikes of low anticlinals passing off northwardly beyond the edge of the monoclinal. These effects were more fully discussed in my article on "The Ozark uplift." There are no rocks of later age than the upper Carboniferous in this lower district. The effects of the uplift are alike along the Missouri and the Mississippi. One who has observed these features will readily come to one, and only one conclusion—THEY ARE OF THE SAME AGE. In what way the lower and the upper rivers came to be connected has yet to be demonstrated. It took place either in very late Tertiary or just subsequently. There undoubtedly were streams tributary to the great Laramie lake, and the upper Missouri (above the "falls") may have been a developed tributary. While the lake dried out during the later Tertiary, various fissures were opened, channels for streams worked their way along the descending slope, and through these fissures the waters of the upper Missouri passed and united with the lower river.

After the Archæan there was a period of quiet, permitting the deposit of 30,000 feet of strata in the eastern United States; during the same time in Missouri 1,500 to 2,000 feet were deposited, including the Magnesian limestone series of south Missouri. The total Palæozoic series in Missouri amounts to about 5,000 feet.

The greater portion of the Ozark plateau has been dry land

[1]This journal. Jan. 1889.

since the close of the Canadian period, but it has been more or less subjected to slight oscillations from that time to the Permian. It began to rise just after the Canadian. It was above the waters before the Trenton period. From the Canadian to the beginning of the Lower Carboniferous it was dry land. It then became sufficiently depressed to receive limestone deposits near its outer margin during the early Subcarboniferous, a few beds of later Chouteau, and early Burlington. This was the last period of submergence of any part of the Ozarks. It again was subjected to elevation before the era of the Keokuk, and was subjected to slight throes incidental to the uplift, which did not cease until after the Coal Measures were deposited, but this was continued through a long succession of time but ceased at the close of the Palæzoic, its latter stage contemporary with the Appalachian revolution.

During the Glacial and succeeding Quaternary, the lower river was filled with boulders, sands and pebbles, now found in its bed. That the Missouri as well as the Mississippi was dammed or gorged at many places seems evident from the silt-like deposits now so thickly strewn along the neighboring hills, and to which the term "Loess" has been applied. The drift abounds in north Missouri but is rarely found south of the Missouri, and I have recognized it only at about three localities 5 and 15 miles from the Missouri. In Illinois it is limited by the Ohio. From the southern limit it extends away north. The Loess is well recognized only near the Missouri and the Mississippi; I speak of the lower Missouri. Its origin as well as that of the present silt along the Missouri is from the "Bad lands" of the upper river.

For 400 miles below Ft. Benton the Tertiary and Cretaceous are weathered into curious forms, and as far down as Judith river are numerous trap dikes causing rapids. For 600 miles on the upper river are occasional outcrops of lignite and most of that portion presents the well known "bad land" scenery. The rocks are often weathered into many curious forms and a common feature is many standing columns forming numerous monument-like groups similar to those in the "Garden of the Gods," Colorado. These are a very interesting feature of the scenery of the upper Missouri.

To the Palæozoic cliffs of the lower river are given names which have become historic, as "Tavern rock," "Big" and

"Little Blossom," "Arrow rock," etc., and on the Mississippi, "Bake Oven," "Grand Tower," etc. The lower Ohio, (probably all of the river) the upper Mississippi (above the Ohio) and the lower Missouri are all of the same geological age. Beginning at the close of the Palæozoic or a little before, they were soon after developed into lively running streams. The Missouri was probably a clear stream until joined with the upper Missouri after the later Tertiary.

University, Columbia, Mo., July, 1889.

THE MESOZOIC SERIES OF NEW MEXICO.

I.

By Jules Marcou.

The June number of The American Geologist contains a paper by Prof. J. J. Stevenson, "The Mesozoic rocks of southern Colorado and northern New Mexico," pp. 391-397, based on such inexact principles that it confuses all the stratigraphy of four systems of rocks, the Carboniferous, the Trias, the Jura and the Cretaceous. At the end of his paper professor Stevenson makes use of language such that it is impossible even to quote it. However I shall answer him, in order to give a little more light, taking special care to stay only on the ground of geological facts observed in the field, and published in official reports, or in scientific periodicals.

1853, Marcou.—New Mexico was geologically a complete *terra incognita* in 1853, when I reached it, after passing over another *terra incognita* from Little Rock, Arkansas, to the Llano Estacado. The Carboniferous system had been recognized in Iowa, Nebraska, Missouri and Arkansas, and its existence had been signalized also on the San Saba river in Texas, and at Great Salt lake. The Cretaceous system was known to exist on the upper Missouri river, in Texas, and at Poblazon (New Mexico), without any attempt at any classification or synchronism with the Cretaceous of the eastern and southern states, and even less with Europe; except for the vicinity of New Braunfels in Texas, where Dr. F. Rœmer had worked out the Cretaceous strata, giving a classification and synchronism, which on the whole has proved incorrect ("Texas." von Ferdinand Rœmer, p. 373, Bonn. 1849). After passing over Delaware mountain or ridge (about 97° longitude and 34° 60′ latitude in the Indian territory, Chikasaws nation), I entered

into the New Red Sandstone series (Dias and Trias systems); and after traveling westward for hundreds of miles I met first the Neocomian, with a well characterized fauna at Comet creek (99° longitude and 35° 50′ of latitude) resting uncomformably upon the middle part (Muschelkalk) of the Triassic system; and secondly the Jurassic system lying in concordance of stratification over the upper part (Keuper) of the Trias at Encampment creek on the Llano Estacado, but without fossils, and farther on at Pyramid mount, Tucumcari and Plaza larga area (longitude 101° to 104° and latitude 35° 10′) with a fauna of Jurassic *Ostraceæ* containing the most characteristic European forms. On reaching the settlements in New Mexico I found at Galisteo the upper Cretaceous or white chalk formation of Europe characterized by a genus of fossil fish, *Ptychodus*, confined until then to the white chalk of England and France; and besides I recognized west of Galisteo, a Cretaceous area which extends across the Rio Grande del Norte, forming all the mesa between Albuquerque and the Rio Puerco.

I will present my stratigraphical observations and classification of the strata of New Mexico, the Pan Handle of Texas and the Indian territory, as I made it in 1853, in the following detailed table.

I.—Table showing the order of succession and classification of the Mesozoic series along the 35th parallel of latitude, between Delaware ridge (Indian territory, Chickasaw nation). Zuni, (New Mexico), and San Francisco mountain, (Arizona), 1853.

CRETACEOUS SYSTEM.	Upper Cretaceous or White chalk. (New Mexico.)	a. Gray sandy marls, with *Ptychodus whipplei*, *Ammonites*, *Inoceramus*, *Ostrea congesta;* north of Galisteo, lying in discordance of stratification over or against the white and yellow Jurassic sandstone. b. Black marls and sandy limestone with *Inoceramus Lerouxi;* Ravines of the Rio Galisteo. c. White sandstone, with *Ammonites novi-mexicani*, *Baculites* and *Inoceramus*. It forms the whole mesa between Albuquerque and the Rio Puerco.	
	Break.		
	Middle Cretaceous or Green sand.	Greenish marly limestone, with scales of fossil fishes. Seen only at Shawnee village, at the junction of Little river with the Canadian river.	Unknown in New Mexico.
	Lower Cretaceous or Neocomian. (Indian Territory.)	a. Pale blue marl of Fort Washita and near Preston (Texas), with *Gryphæa sinuata* var. *Americana*, *Exogyra texana*, *Ostrea carinata*, *Holaster comanches*, *Ammonites peruvianus*, *Am. belknapi*, *Am. shumardi*, etc. b. Yellow Gryphites limestone of Comet creek and Fort Washita with *Gryphæa pitcheri*.	Unknown in New Mexico.
Break.			
		I. White limestone, similar to the white limestone of the White Jura of Wurtenberg and the Jura. It forms the summit of Pyramid mount, Tucumcari area. No fossil collected. 2 feet.	

JURASSIC SYSTEM.		II. Yellow limestone, similar to the yellow limestone so common in the Jura Pyramid mount. No fossils collected; 50 feet. Pyramid mount. III. Blue-gray clay, similar to the Oxford clay of the Jura and southern England. Pyramid mount. A bed is full of well preserved *Gryphæa dilatata* var. *Tucumcarii* and a rare *Ostrea marshii;* 30 feet. Pyramid mount. IV. White and yellow sandstone. No fossils collected; 113 feet. Pyramid mount. *Nota bene.*—At Encampment creek, northern part of the Llano Estacado, in the Panhandle of Texas, I have found the Jura formed at the top of white chalky limestone, then calcareous conglomerate, then limestone and finally sandstone containing numerous calcareous concretions. Broken fossils undeterminable. From Tucumcari area the Jurassic rocks continue westward to Canon blanco, covero Inscription rocks and canonito Bonito. The sandstones (II) are divided by marls and yellow limestones with two seams of bituminous coal near Zuni. At Covero I have collected a *Gryphæa*, allied to *G. calceolata*.	
TRIASSIC SYSTEM.	Keuper.	a. Variegated marls or *Marnes iridees*, most beautifully developed at Pyramid mount; 500 feet; no fossils collected Seen from the foot of the Llano estacado to Zuni. b. Whitish-gray sandstone, often rose colored and even red; 1,000 feet. No fossils collected. Seen from Antelope hills to Antochico and Zuni.	
	Muschelkalk.	a. Saliferous clay and rock salt. b. Gypsum. c. Magnesian limestone. d. Red clay with gypsum.	1,500 feet. Numerous fossil woods in the Indian territory and also at Lithodendron creek, and a fragment of a bivalve *cardinia ?* (Arizona). Seen between Rock Mary to Shady creek (Indian territory), and also at San Antonio and west of Zuni.
	Bunter Sandstein.	a. Argillaceous red sandstone. b. Red sandstone and conglomerate.	2,000 feet. No fossils collected. Seen from old fort Arbuckle or Beavertown to Rock Mary (Indian territory), at Tijeras, and on the Colorado Chiquito between Lithodendron creek and Canon Diablo.
DYASSIC (*Permian*) SYSTEM.		Magnesian, or dolomitic limestone, or Permian; west of the Rio Colorado Chiquito, between Canon Diablo and Cosnino caves; fossils taken from me and placed in unfriendly hands; they were never published or referred to. Blue clay sandstone and dolomitic limestone in the Topofki creek area (Indian territory). No fossils collected.	
Break.			
CARBONIFEROUS SYSTEM.		Blue-black and gray limestone and marls with a rich Carboniferous fauna, more especially *Brachiopoda.*—Delaware ridge (Indian territory): Pecos village, Tijeras. Sierra de Sandia and Sierra de Zuni (New Mexico); and west of the San Francisco mountains (Arizona).	

All my observations were carefully checked while in the field and afterward I took care to publish them with minute exactness both as regards the text and as to geological maps, sections and plates of fossils. Prevented by Jeff Davis, then Secretary of War, from publishing my report in full—a case unique in government official reports—I was obliged to have recourse to foreign periodicals, and finally to publish my observations at my own expense, in the English language and in a foreign land, at Zurich (Switzerland). Here are the titles of the principal papers and memoirs, in which are in-

serted in full my researches along the 35th parallel of latitude (1) "Resumé of a geological reconnoissance extending from Napoleon, at the junction of the Arkansas with the Mississippi, to the Pueblo de los Angeles in California." (*Report of Secretary of War.* House Document 129, in Lieut. A. W. Whipple's *Report of explorations near the thirty fifth parallel*, chapt. VI, pp. 40-48. Washington, 1855.) A corrected edition of that résumé was published at the end of vol III, pp. 165-171, of the quarto edition of the *Pacific railroad explorations.* Washington, 1856. (2) "Geological notes of a survey of the country comprised between Preston, Red river and El Paso, Rio Grande del Norte." *Rep. Sec'y War*, House Document 129, in Bvt. Capt. John Pope's *Report of explorations near the thirty-second parallel*, chapt. XIII, pp. 125-128. Washington, 1855. (3) "Resumé d'une carte geologique des Etats-Unis et des Provinces Anglaises de l'Amerique du Nord, avec un profil geologique allant de la vallée du Mississippi aux côtes du Pacifique et une Planche de fossile" (*Bulletin Soc. Geol. France*, t. XII, pp. 813-936, Paris 21 Mai, 1855). This geological map is the first map giving the Geology west of the Mississippi river to the Pacific; along the 35th parallel, the age of the rocks, their position and geographic distribution are exactly given; outside of the road followed by the expedition the geology is only approximative, as no geologist had ever traveled over the ground. The geological profile or general section from the Mississippi river to Los Angeles is the only general geological section we possess even to this day of the country extending between the Mississippi basin and the Pacific shores; finally the plate of fossils made by Humbert, the artist who drew the fossils of Barrande and Deshayes, and who was considered the first draftsman of his time, represents the *Ostraceæ* found by me in the Jurassic system and the Neocomian of New Mexico and the Indian territory, and is the best and most beautiful plate of invertebrate American. Mesozoic fossils published even to this day. (4) "Geology of North America, with three geological maps and seven plates of fossils." 4to Zurich, 1858. One of the maps represents the geology of central New Mexico from the Llano estacado to the west of Zuni, scale, 1 :900,000. It is not only the first detailed geological map of New Mexico, but the only one which gives a rational classification and exact distribution of the rocks even

though more than thirty years have elapsed since its publication. The Mesozoic fossils are represented on five plates, well executed, and they are described under the names of: *Ptychodus whipplei*, *Ammonites shumardi*, *Am. belknapii*, *Am. peruvianus*, *Am. gibbonianus*, *Am. novi-mexicani*, *Hamites fremonti*, *Inoceramus lerouxi*, *Isocardia washita*, *Gryphæa sinuata* var. *americana*, *Gryphæa pitcheri*, *Holaster comanchesi*, *Gryphæa dilatata* var. *tucumcarii*, and *Ostrea marshii*. (5) "Letter on some points of the geology of Texas, New Mexico, Kansas and Nebraska," Zurich 1858. And finally (6) "Une réconnoissance géologique au Nebraska." (*Bull. Géol. Soc. France*, vol. XXI, pp. 121-146, Paris, 18 Janvier 1864).

Now let us give by order of dates the classifications of the geologists who have succeeded me, covering either partly the ground traveled over by me, or who without going at all into the field, have, however, expressed their views on the classification of strata and on Mesozoic fossils found in the same area

1857, HALL.—Mr. James Hall, after having in his hands without my consent or even knowledge, my specimens,* and my field-notes book, besides making use of my general geological map of the United States, with the geological section from the Mississippi river to Los Angeles, and the plates of Mesozoic *Ostraceæ*, came to the following conclusions, which he recorded first in 1856 (*Pacific railroad explorations*, 4to edition, vol. III, chapter IX), and second in 1857 (*Mexican boundary survey*, vol. I, pp. 135-136.) Here is his table of classification:

II.—Table showing the order of succession and classification of the Mesozoic series of Texas, the Indian territory and New Mexico, by James Hall, 1857.

TERTIARY FORMATION.		
CRETACEOUS FORMATION of Nebraska.	Upper and Middle Cretaceous.	V. Arenaceous clay=Fox Hill group.[1] IV. Plastic clay=Fort Pierre group. III. Calcareous marl=Niobrara division. II. Clay=Fort Benton group.
	Lower Cretaceous.	I. Sandstone and clay=Dakota group.
CARBONIFEROUS FORMATION.		

* They were placed in his hands by order of the Chief of Engineers, through Mr. W. P. Blake.—[Ed.]

[1] In 1861, Meek and Hayden applied geographical names to the various divisions, retaining, however the original numbers. (*Proceed. Acad. Nat. Sci.*, Philadelphia.)

If we compare this table with table I, we see that Mr. James Hall has placed in his Lower Cretaceous No. I=Dakota group, all the strata above the Carboniferous system, recognized by me in 1853 as belonging to the Neocomian, the Jurassic system, the Triassic system and the Dyassic (Permian) system; nullifying all the stratigraphy, the lithology, and what is worse, also the palæontology.

It is a mistake similar to that of placing 25,000 feet of pre-Potsdam strata, called Taconic system by Dr. Emmons, in parallelism with the Hudson River group and the Oneida conglomerate; Mr. Hall going so far as to use the same expressions of "unquestionable," "unequivocal,"applied in both cases to fossils and series of strata, which he tried to suppress. And in order that no equivocal understanding may be applied to his classification, he has colored on a geological map entitled: "Map illustrating the general geological features of the country west of the Mississippi river" all the road explored by me from Delaware ridge (Indian territory) to the Tucumcari area (New Mexico) as covered only by the Dakota group or Lower Cretaceous No. I, which singularly enough does not exist there in a single spot.

That classification has been accepted, defended and used in papers, in manuals and in geological maps until 1887, by Messrs. J. D. Dana,[1] Meek,[2] W. P. Blake,[3] the two brothers Drs. Shumard,[4] C. H. Hitchcock,[5] R. H. Louhgridge[6] and W. J. McGee.[7] An extensive literature based on it exists, of which I give here only a small portion.

The determination of my Mesozoic fossils by Mr. Hall has been accepted, defended and used in all the palæontological papers, or stratigraphical papers in which lists of fossils have

[1] *Amer. Jr. Sci.* vol. XXVI and XXVII, 1858-59. *Manual of Geology*, etc.

[2] *Proceed. Acad. Nat. Sci.;* Philadelphia, 1857-60.

[3] *Amer. Jr. Sci.*, vol. XXII, 1856. *Pacific railroad explorations*, 4to edition, vol. III, and vol. II, 1856.

[4] *First report of the geographical survey of Texas*, 1859. *Trans. Acad. Sci., St. Louis*, 1860-61. *A partial report of the geology of western Texas*, Austin, 1886, etc., etc.

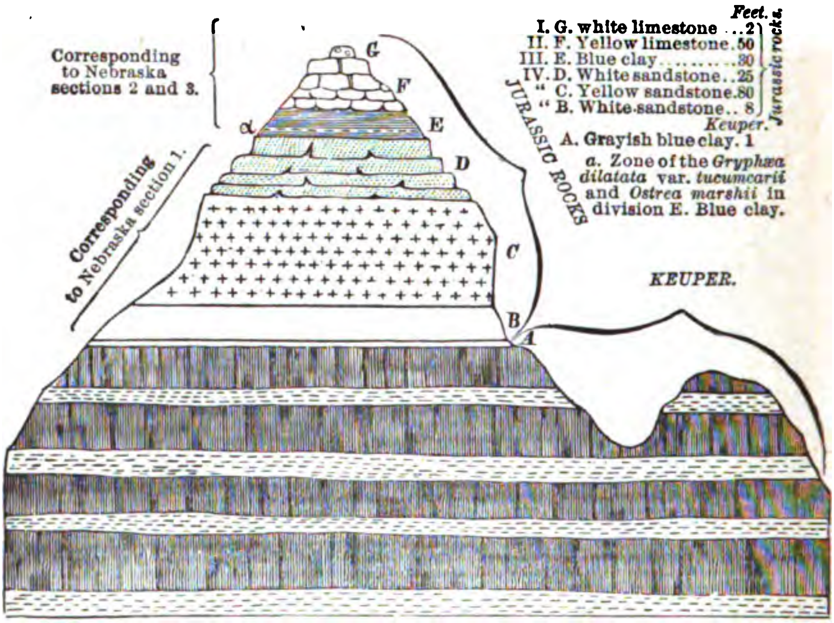
[5] *Geological map of the United States*, compiled for the 9th census, 1872. *Geological map of the United States and part of Canada*, compiled for the Amer institute of mining engineers, 1886, etc.

[6] *Ninth census. Report on cotton production in the United States*, 1884.

[7] *Map of the United States exhibiting the present status of knowledge relating to the areal distribution of geologic groups*, 1884. (*Fifth Ann. Rep. U. S. Geol. survey.*)

been given, until 1887. And more, until now, it has been the custom among palæontologists to quote all the fossils described and figured by their predecessors; but an exception has been made for me, and Dr. Benjamin F. Shumard, F. B. Meek, and Dr. Charles A. White have simply passed over my palæontological work on the Mesozoic fossils of Texas and New Mexico, as if it did not exist. Dr. C. A. White goes so far in his "Review of the fossil Ostreidæ of North America" (*Fourth Ann. Rep. U. S. Geol. survey*, 1884), as to give as a new species, under the name *Exogyra walkeri*, an enormous *Gryphæa*, the largest existing in America, which I have described with a splendid figure as *Gryphæa sinuata* var. *americana*, thirty years before him; and he adds that the *G. pitcheri* described by Morton was originally discovered in the Cretaceous strata of New Jersey, contrary to the printed opinion of Dr. Morton and where the *G. pitcheri* does not exist. Finally on plate XLIX, he gives Fig. 3, the lower valve of my *G. dilatata* var. *tucumcarii* as belonging to the *G. pitcheri*, thus adding to the confusion introduced by the determinations of Mr. Hall. The only geologist who has quoted my Mesozoic fossils of Texas, is professor Robert T. Hill, in his paper: "The Texas section of American Cretaceous" (*Amer. Jr. Sci.*, vol. XXXIV, 1887) and he, probably misled by the determination of Mr. Hall, has confounded the *G. dilatata* var. *tucumcarii* with the *G. pitcheri;* and the *Ostrea marshii* with the *Ostrea subovata;* only now, after a visit to the Little Tucumcari mountain, in September, 1888, he is convinced that the *Gryphæa tucumcarii*, is an entirely different species from the *Gryphæa pitcheri*, and was rightly referred by me to the Jurassic type of *Gryphæa dilatata*. As the main part of the controversy and the principal ground for the rejection by Mr. Hall and his associates of the existence of the Jurassic system at the Tucumcari area is based on the erroneous identification of the *Gryphæa tucumcarii with the Gryphæa pitcheri*, I shall quote Mr. Hall's own words:

"In a section of Pyramid mount given by Mr. Marcou (*Bulletin Soc. Geol. de France*, tome XII, p. 878) he recognizes a series of sandstones and clays beneath limestones, which are of *unquestionable* Cretaceous age.



"The explanations of the section quoted above are those given by Mr. Marcou. The designations at the right hand are those given by him in the text accompanying the section."— The designations given at the left hand are those given by Mr. Hall (*Mexican boundary line*, p. 135, vol. I, Washington, 1857).

Mr. Hall adds, p. 136: "Having examined the specimens in Mr. Marcou's collection from this locality I have no hesitation in saying that the specimens labelled by him as *Gryphæa tucumcarii* (*G. dilatata* var. *tucumcarii*, *Buil.* soc. geol. de France, tome XII, pl. 21) are the *Gryphæa pitcheri* of Morton and present no features either in forms, characters, or condition of preservation, or otherwise, which can serve to distinguish them from *Gryphæa pitcheri*, in the boundary survey collections, from strata forming a continuation of the Llano Estacado."

Mr. Hall has figured and described my specimens from Pyramid mount, and from Comet creek, in *Pacific. R. R. explorations*, vol, III, pp. 99-100. The *G. tucumcarii* figured was chosen from some rolled and badly preserved specimens;

and notwithstanding this it has absolutely nothing in common with the *G. pitcheri* figured on the same plate. The description is inexact and fails completely to give an idea of the fossils; and besides the assimilation that Mr. Hall attempts to make with the *G. vesicularis* of the white chalk is as faulty as it is possible to imagine, for the two *Gryphæa* have no resemblance whatever.

As to the *Gryphæa pitcheri* which Mr. Hall calls var. *navia*, it is the true *G. pitcheri* of Morton and Rœmer, found by me at Comet creek near the False Washita river. Mr. Hall has copied on his plate the figures of my plate of the *Bulletin soc. geol. de France*, and he was plainly so little acquainted with the fossil that he put fig. 10 as the side view of fig. 9, when it is the side view of the upper valve of *Gryphæa tucumcarii*, which has nothing to do with the Comet creek specimen. Mr. Hall is also incorrect in the locality given (*Pacific R. R. explorations*, vol. III, p. 100), saying: "The same (*G. pitcheri* var. *navia*) has likewise been brought from numerous other localities in the west." That *Gryphæa* has actually never been found in the west, and the numerous palæontological publications of Meek do not make any mention whatever of its existence in a single western locality. It was never found outside of the Indian territory and Texas, and last year only in southern Kansas, which seems to be its northern limit.

One example, among many which could be quoted, will show the influence exercised by the erroneous determination of my Jurassic fossils of the Tucumcari area by Mr. Hall: "Although some of the strata which Mr. J. Marcou described as Jurassic and Triassic are, perhaps, of that age, still he based his conclusions chiefly upon fossils which have since been recognized as Cretaceous forms." (*Explorations across the Great Basin of Utah in 1859.* Simpson. Geology by H. Engelmann, p. 274, Washington, 1876).

Everything is so inaccurate in Mr. Hall's identifications, descriptions and figures that we are driven to the conclusion that his knowledge of the genus *Gryhæa* is well nigh a blank, as well zoologically as geologically.

1858 AND 59, NEWBERRY.—In 1858 Dr. J. S. Newberry made a reconnoissance in New Mexico which touched my road of 1853 from Aztec Pass in Arizona, to Pecos village. Here is the résumé of his classification:

III.—Table showing the order of succession and classification of the Mesozoic series of New Mexico, by J. S. Newberry, 1858.

CRETACEOUS. SYSTEM.	Upper Cretaceous of the white mesa, Moqui country. Lower Cretaceous=Dakota group or Lower Cretaceous No. 1. In it at Moqui village, Dr. Newberry says that he found the *Gryphæa pitcheri* of the Neocomian of Comet creek and fort Washita (Indian territory).

Dr. Newberry declares that there is *no Jurassic system* on the route followed by Mr. Marcou from Zuni to Pecos village. But at the Moqui Pueblo—not visited by Marcou—he found a lignite or coal bed, which he is inclined to consider either as Jurassic (?) or Upper Trias. (?) In his sections and on the geological map, that lignite bed is included in his division of "Variegated marls."

TRIAS. (in part).	Variegated marls of the Moqui country, comprising the Saliferous sandstone and Salt group of the fort Defiance country and of the vicinity of Pecos village.
PERMIAN or TRIAS.	Red sandstone formation and Magnesian limestone of Mr. Marcou, at the crossing of the Rio Colorado Chiquito. Blood red and yellow marble of Cascade river, called Permian by Mr. Marcou. (I never saw Cascade river.—J. M.)

CARBONIFEROUS SYSTEM, at Cascade river.

The geological report of Dr. Newberry is published in the volume of the "Colorado exploring expedition," Lieut. J. C. Ives, 4to, Washington, 1861. It contains three plates of fossils and two geological maps. In the geological map No. 2, Dr. Newberry not only suppresses the Dyas (Permian), which he admits in a certain degree in his report, but he also colors as Carboniferous a large area of Trias, from Big Dry Fork to Cascade. He colors the Trias on only half the area it really occupies there, and as I colored it on my geological map of New Mexico of 1853, and on my general geological map of the United States of the same date, and finally Dr. Newberry colors on his map No. 2 as Cretaceous, not only the Cretaceous beds there, but also all the Jurassic system and all the Keuper of the Triassic system, which covers large areas between Moqui and Zuni.

Dr. Newberry has "failed to recognize the Jurassic formation in any of the localities where it has been said to occur" by Mr. Marcou, referring it to the Cretaceous of the upper Missouri valley or marly chalk (Turonian) "the Triassic formation of Mr. Marcou" is so much reduced, that its thickness is only

half of what I said it was; and as to the recognition of the Bunter sandstein, the Muschelkalk and the Keuper, Dr. Newberry said, whether those three formations "will ever be fully identified in New Mexico, I regard as doubtful."

So that Dr. Newberry in his exploration of New Mexico of 1858, five years after my exploration of 1853, and with all my publications available, did not recognize the Dyas (Permian), admitted reluctantly half the thickness of strata which I have referred to the Triassic, did not recognize the Jurassic system at a single place where I had located it, and finally recorded the existence of the *Gryphæa pitcheri*[1] of the Indian territory and Texas, at Moquis Pueblo, at Cañoncito Bonito, at Covere and on the bank of the Rio Pecos, which if it had been proved correct by the numerous explorations made since, would have shown that Dr. Newberry had discovered the Neocomian in New Mexico.

(TO BE CONTINUED.)

GLACIATION OF MOUNTAINS IN NEW ENGLAND AND NEW YORK.

By WARREN UPHAM.

Read before the Appalachian Mountain Club, April 17, 1889.

I.

Mountains have special interest for the glacialist in their testimony of the direction of the currents of the ice-sheet and its maximum thickness; and nowhere are mountains more instructive in this respect than in New England and New York. If we include also northeastern Pennsylvania, we find here the only summits that stood above the surface of the ice-sheet on the north-eastern part of this continent, excepting that in northern Labrador, adjoining Hudson strait, mountains similarly rose above it. The top of Katahdin, of Mt. Washington, and of the Adirondacks projected above the ice during the greater part of the epochs of glaciation, but, excepting Katahdin, were wholly covered when the ice attained

[1] Professor Robert T. Hill has proved since 1886 that the original *Gryphæa pitcheri* is the most characteristic fossil of the Neocomian of Texas. Lately, January 1889, professor Francis W. Cragin has recognized the Neocomian, characterized by the original *Gryphæa pitcheri* at Belvidere (Kansas), on Medicine river, south of the Great bend of the Arkansas river, and has traced it even as far north as McPherson county, north of the Arkansas, which is the northern limit of *Gryphæa pitcheri* and of the Neocomian (*Bulletin Washburn college*, vol. II, No. 9, p. 35, Topeka, Kansas).

its greatest depth. That this is true of Mt. Washington is shown by rare transported bowlders found by professor C. H. Hitchcock on this highest summit of the White mountains, 6,293 feet above the sea.

In the Ice Age, the latest completed period of geologic history, the climate of the northern half of North America became very cold, with so much precipitation of snow that the summer's heat was not sufficient to melt it. The depth of the snow therefore slowly increased from year to year, until its lower portion became changed to ice by the pressure of its own weight, as glaciers are formed in the Alps, and as an ice-sheet now covers the interior of Greenland and another surrounds the south pole. In our country the southern limit of the ice-sheet in its maximum extent reached from Nantucket, Martha's Vineyard, and Block Island westward along the terminal moraine, which is commonly called the backbone of Long Island, across northern New Jersey and Pennsylvania, southern Ohio, Indiana and Illinois, central Missouri, and northeastern Kansas; thence it extended northwestward through Nebraska and Dakota; and from the vicinity of Bismarck trended again westward through northern Montana, Idaho and Washington.

North of this boundary the land was deeply covered by ice, as is known by its transported boulders and drift, and by its striæ, which are furrows and scratches engraved on the bed-rock over which the ice moved, as fragments of stone frozen in the bottom of alpine glaciers wear the underlying rock surfaces. Toward the northeast from Nantucket and cape Cod this ice-sheet probably terminated on the remarkable submarine plateaus known as the Fishing banks; and on the west it pushed into the edge of the Pacific, across the islands that border the coast of British Columbia and Alaska. About a quarter part of the United States, the entire Dominion of Canada, the area of Hudson bay, and probably much of Alaska and of the large islands in the Arctic sea between the mouth of the Mackenzie and Baffin bay, were wrapped in a sheet of ice, which was replenished by the yearly snow-fall and was caused, by the pressure of the vast weight of its central portion, to flow slowly outward on all sides. Its greatest depth, estimated by professor Dana to have been about two miles, was on the highlands between the St. Lawrence and

Hudson bay, as is indicated by the general divergence of striæ and dispersal of drift from that region; but a nearly equal depth of ice seems to have extended thence westward to lake Superior and over the area of James bay and the southern part of Hudson bay to the vicinity of lake Winnipeg and Reindeer lake.

Similarly, northwestern Europe was covered by an ice-sheet which moved radially outward in all directions from the mountains of Scandinavia, extending southeast and south over about half of Russia and Germany, and southwest across the area of the North sea to Britain, where the mountains of Scotland, Wales, and Ireland, were smaller independent centers of glacial outflow. Farther to the south, a large area in the Pyrenees, and a still larger district in the Alps and adjoining country were covered by ice. In North America, likewise, the Rocky mountains and the Sierra Nevada bore glaciers of great extent along a distance of several hundred miles south of the continental ice-sheet; but no such local glaciation is known along the Appalachian mountain belt south of the general boundary of the drift.

Alpine glaciers are wholly inadequate to give a mental picture of the North American and European ice-sheets, though they suggested to Louis Agassiz fifty years ago the grand generalization that the drift of these northern countries was formed by land-ice covering continental areas, as the ancient glacier of the Rhone poured westward from the Finsteraarhorn, the Jungfrau, Monte Rosa, and Mont Blanc, across the great valley of Switzerland where now are the lakes of Geneva and Neuchatel, to the Jura range on which its immense bowlders are stranded. Even that former extension of ice from the Alps was small in comparison with the ice sheet of northwestern Europe, which stretched 2,000 miles from west to east, with a maximum width of 1,500 miles; and the North American ice-sheet had far greater extent, reaching 4,000 miles from Newfoundland and Labrador to the Pacific ocean and Alaska, and from the Ohio, Missouri and Columbia rivers to the Arctic ocean. The only similar tracts of ice now existing upon the globe are the Antarctic ice-sheet and that which occupies the interior of Greenland.

Around the south pole an ice-sheet extends outward on all sides, to an average distance of 1,000 miles or more from the

pole. It everywhere terminates in the sea, and, because it is lifted up by the ocean and broken into bergs, its margin has the form of a vertical wall, along which Sir J. C. Ross sailed four hundred and fifty miles, finding only one point sufficiently low to allow the upper surface of the ice to be seen from the masthead. There it was a plain of snowy whiteness, reaching as far as the eye could see.

In Nordenskiöld's journey on the ice-sheet of Greenland, to the east from Disco bay, he found that its surface rose to a hight of about 2,500 feet in a distance of fifty miles; to 5,200 feet, or nearly one mile in a hundred and sixty miles; and to 6,465 feet in three hundred miles. The average ascent of the ice surface in the first fifty miles, including the more rapid rise near the margin, is about fifty feet per mile, or slightly more than half of one degree; in the next hundred and ten miles it is about twenty-five feet per mile; and in the remaining hundred and forty miles, lying near the center of Greenland, the ascent is only nine feet per mile.

On the Antarctic continent (if it be not a group of islands united by the ice-sheet) the volcanoes Terror and Erebus, seen in eruption by Ross, rise to hights of about 10,000 and 12,000 feet. The greater part of Greenland has no mountains of similar hight, and after ascending upon the border of the ice-sheet, which is reached at the head of the fiords not far back from the coast, occasional ridges and hill-tops are found rising out of the ice during the first day's journey upon it, beyond which there is a slightly undulating expanse of ice and snow, appearing in a broad view as level and illimitable as the ocean, and bounded only by the encircling smooth horizon. The surface of this ice-sheet in its central part has a similar altitude with the highest mountain summits of New England and New York, and it overtops the most elevated points of the land on which it lies.

Such too was the ice-sheet of the northern United States and Canada, whose border covered the northeastern part of the Appalachian mountain system, from northern Pennsylvania to where the headland of Gaspé projects into the gulf of St. Lawrence. Within this area five prominent mountain masses deserve special consideration in respect to their glaciation: namely, Katahdin, the White mountains, the Green mountain range, the Adirondack group, and the Catskills.

We may profitably note in successive order the observations which have been gathered concerning the striation and drift of these mountains, that we may learn which of them stood above the ice as landmarks when it attained its greatest depth, and in what direction the glacial current passed over the sides of these and over even the tops of the others. All the lower mountains and hills of the New England states, and New York, and of Ontario, Quebec and the eastern provinces, were enveloped by ice, and bear its typical marks of striation and deposits of drift from base to summit.

The descriptions of Mt. Katahdin, or Ktaadn, by Jackson, Hitchcock, Packard, and Hamlin, give us very ample and clear knowledge of its glaciation. According to president M. C. Fernald's determinations, this highest mountain of Maine rises 5,215 feet above the sea, and the latitude of its summit is 45° 53′ 40″. Its distance north-northwest from the boundary of the ice-sheet, which lay probably outside the gulf of Maine, was about two hundred and fifty miles.

Dr. C. T. Jackson's ascent of Katahdin, in the prosecution of his labors as state geologist, was accomplished Sept. 23, 1837, under great difficulties from deficiency of provisions; and the top was reached in a furious northeast snow-storm, which made it impossible to obtain detailed observations. He determined the elevation approximately by barometer, and noted important topographic features, the limit of the forest, a few of the plants seen at greater hights, and that the mountain is composed entirely of granite. At that time the drift was little understood, though beginning to attract the attention of geologists; and Dr. Jackson expressed the opinion that it had passed over this summit.[1]

Twenty-four years later, in August, 1861, professor C. H. Hitchcock, state geologist, ascended Katahdin, accompanied by G. L. Goodale, as botanist, and A. S. Packard Jr. as entomologist. The party passed along the very narrow, sharp ridge, running westward with precipitous descent on each side, that joins the peak of Pomola with the east and west peaks, the latter of which is the highest point of the mountain. "We never imagined," writes professor Hitchcock, "that in our New England mountains, localities could be found so nearly

[1] Second annual report on the geology of the public lands of Maine and Massachusetts, Augusta, 1838.

resembling the peaks and ridges of the Andes. Instantly the idea occurred to us that such a narrow ridge could never have been shaped by drift action. Its sides are covered with those loose angular blocks which frost has removed from the ledges but drift has never transported, precisely like the fragments upon the top of Mt. Washington above the drift region. We searched in vain over all the top of Mt. Katahdin for any signs of drift action. There are no striæ upon the ledges, no smoothing or rounding of the rocks, and no transported bowlders anywhere upon the summit. This view is strengthened by the fact that there are no transported rocks in the Basin, into which an innumerable quantity of bowlders would have been hurled if the drift agency had ever crossed the summit.

"Only one feature appeared favorable to the view that the drift passed over the top. The whole of the northwest side of the summit appears like one great stoss side, while the lee side is very ragged, just as would be the case if the ice went over the top. But in answer to this it may be said, this apparent stoss side is only the natural shape of the mountain, and its position accidental. This view is partially confirmed by the fact that for a great distance from the summit on the northwest slope no ledges can be seen, only the fragments which have been loosened by frost. Generally, when ledges have been struck by drift, even if the scratches are obliterated, the rocks are not so thoroughly split up by frost but that the rounded ledges remain very slightly affected. This is certainly the case upon Mt. Washington. The drift force seems often to have been strong enough to remove all the loose and prominent parts of ledges, leaving the solid foundation so firmly rooted that atmospherie agencies have not yet had time enough to break them up. We are fully satisfied that a large part of the Katahdin summits have never been swept over by drift, even if we must believe that the highest portion has been struck."[1]

Professor A. S. Packard, Jr, compares the aspect of the top cf Katahdin, "strewn thickly with huge angular blocks broken off by frosts from the subjacent strata," with Mt. Washing-

[1] Sixth Annual Report of the Secretary of the Maine Board of Agriculture, 1861.

ton and adjacent peaks of the same range, and with the mountains of gneiss in northern Labrador, near cape Chudleigh, which latter in their lower part are rounded and moulded by ice, but above present more angular and irregular outlines, and are profusely covered with loose blocks detached by frost.[2] The elevation of the highest part of the coast range of Labrador, seventy miles south of cape Chudleigh, is estimated by Dr. Robert Bell to be about 6,000 feet above the sea; and he states that throughout the drift period its top "stood above the ice and was not glaciated."[3]

Photographs of the upper portion of Katahdin, kindly sent me by Mr. George H. Witherle, of Castine, Maine, show well its wonderful profusion of frost-riven rock fragments, quite unlike all the other mountains of New England, excepting the higher part of the range that culminates in Mt. Washington, whose top will be remembered by all who have visited it as having this character. So remarkable is this feature that the ledges fractured by frost at the summit of Mt. Washington are illustrated in the heliotype frontispiece of Vol. I. of the "Geology of New Hampshire." The same condition is found by Dr. George M. Dawson on the upper part of the Three Buttes, or Sweet Grass hills, in northern Montana, which rise 6,200 to 6,483 feet above the sea. These hills stood more than 1,500 feet above the surface of the ice-sheet; for they bear bowlders of the glacial drift in abundance up to 4,600 feet, but no fragments of foreign origin could be found more than sixty feet above that hight.[4] Along the range of the Rocky mountains, also, in Colorado, as I am informed by professor C. E. Fay, frost-riven fragments generally cover the bed-rock on all slopes that are not too steep to allow them to accumulate; and this is finely exhibited in an extensive series of photographs made by Mr. F. H. Chapin, in his mountaineering in that region.

New England presents three types of mountains in respect to glaciation, of which the least frequent is exemplified in this district only by Mts. Katahdin and Washington, with neighboring peaks of the Presidential range, where the surface has not been swept by the current of the ice-sheet, or, if it was at

[2] Memoirs of the Boston Society of Natural History, 1865, vol. I.
[3] Geological and Natural History Survey of Canada; Report of Progress for 1882, 1883, 1884; and Annual Report 1885, vol. I.
[4] Ibid.: Report of Progress for 1882, 1883, 1884.

one time wholly ice-covered, as is demonstrated for Mt. Washington, the time of the glacial envelopment was very brief, not sufficing for the removal of the loose masses which have been fractured by frost from the underlying rock. The second and most common type is represented by Monadnock, where the moving ice-sheet has carried away all the rock-fragments which before the Ice Age doubtless presented generally on all our mountain tops the same appearance as the present summits of Katahdin and Washington; instead of which the surface is now left bare, and rounded in smooth low hummocks of rock on the stoss side,—that is, in New England the north and northwest side exposed to the glacial current,—while on the lee side the slopes are more precipitous and jagged, not being deeply worn by the ice, though usually denuded of their preglacial frost-riven blocks. A third and infrequent type is represented by the northwest slope of Mt. Carrigain, where deposits of glacial drift, analogous with the till of lower areas cover the bed-rock.

Many bowlders and small fragments of Oriskany sandstone, containing characteristic fossils, were found by Hitchcock, Packard, and De Laski,[1] in the drift on the southern slope of Katahdin up to a hight of about 4,000 feet. They were derived from ledges that occur on lakes Webster and Telos, about twelve miles distant toward the northwest. The current of the ice-sheet is thus shown to have moved from northwest to southeast; and in the transportation of these bowlders through so short a distance they were carried upward about 3,000 feet, passing around the west side of the mountain to the slope where they were found.

Special search for these fossiliferous bowlders is reported by professor C. E. Hamlin, in his admirable description of the physical geography and geology of this mountain.[2] He wrote as follows: "Outside of the slides, I have never found drift upon the flanks of the mountain; but it reappears higher up, in very small amount on the Table-Land, but principally upon the northern summits, sparsely strewn among the broken granite that covers them. Neither on slides nor summits is the drift ever found in large bowlders, but always as fragments

[1] American Journal of Science, III, 1872, vol. III, pp. 27-31.

[2] Bulletin of the Museum of Comparative Zoölogy at Harvard College, 1881, vol. VII.

of moderate size. On the southwest slide a few masses were seen as heavy as a hundred pounds each, but in general—always upon the east slide—the pieces ran from a few ounces up to twenty pounds in weight. They were chiefly fragments of slates and sandstones, identical with the strata of the country north and west, mingled with pieces of metamorphic and trappean rocks. . . . Among the scanty drift upon the upper third of the southwest slide, I have never seen a fossil-bearing stone. And upon those parts of the summits where drift was found, only once was a fossil met with,—a solitary brachiopod impression on a ten-pound piece of sandstone, picked up on the slope northward from West peak to the Saddle, about 600 feet below the top of the peak, or at an elevation of about 4,615 feet above the sea. This is by far the highest point at which fossiliferous rocks have yet been found upon Ktaadn."

From these observations it is known that the northern summits of this mountain were ice-covered, the upper limit of the drift being apparently about 4,700 feet above the sea; but the higher west and east peaks, the sharp serrated ridge, the Chimney and Pamola, rising above that hight, appear to be destitute of drift, and probably formed an island projecting out of the continental *mer de glace* during the epoch of maximum glaciation. If we compare the slope of the surface of the ice-sheet with the present sea-level, disregarding the oscillations of the earth's crust which carried the land to a great elevation, as I believe, before the formation of the ice-sheet, depressed it while thus loaded, and partially uplifted it again after the ice was melted away, the average ascent from the glacial border in the Atlantic to Katahdin was about nineteen feet per mile. But if the glacial border was indented within the gulf of Maine, the slope would be greater, perhaps twenty-five feet or more per mile. The greatest thickness attained by the ice upon the country surrounding the base of Katahdin was about 4,000 feet, or four-fifths of a mile. In other parts of Maine the directions of the glacial current, as shown by striæ and transported boulders, were prevailingly S. S. E., with local deflections which bear rarely to the west of south, and more frequently to the southeast or almost due east. Examples of the courses of striæ, from a long list reported by C. H. Hitchcock,[1] are in Fryeburg and Alfred, S. 32° E.; in

[1] Geology of New Hampshire, 1878, vol. III. These and other bearings noted in this paper are referred to the astronomic meridian.

Cornish and Limerick, S. 22° E.; in Portland, at two localities, S. 23° E., and S. 3° E., and in Cape Elizabeth township, S. 8° W., and S. 12° and 22° E.[1] On Mt. Abraham he notes striation S. 59° E., and on the top of Mt. Pleasant, in Denmark, S. 41° W., but on the west side of Mt. Pleasant, near its top, S. 31° to 33° E.

(TO BE CONTINUED.)

THE FORAMINIFERAL ORIGIN OF CERTAIN CRETACEOUS LIMESTONES AND THE SEQUENCE OF SEDIMENTS IN NORTH AMERICAN CRETACEOUS.

BY ROBERT T. HILL.

The writer has recently published a résumé[1] of the occurrence of chalk in the North American Cretaceous, and shown that in the United States there were two distinct and long continued epochs of subsidence within that period, each beginning with arenaceous littorals and insensibly gradating from them, through arenaceous clay shales, clay shales and calcareous shales, into culminating chalk deposits of great thickness and extent.

In the uppermost of these Cretaceous formations, (the Meek and Hayden section and its equivalents) the chalky rocks of the Niobrara horizon have frequently been noted in Kansas and elsewhere. Its continuation and uniformity through Texas and into the southwest corner of Arkansas is so apparent that it need not be discussed here further than to remark that it presents nearly everywhere a uniformity of foraminiferal structure. The sediments of the lower Cretaceous have been less understood, however. Although strata of pure unchanged chalk are occasionally found in them, sometimes accompanied by nodules of the most perfect flints, the greater part of these limestones, through the changes of time are too hard to be longer called of chalky texture. Nevertheless, as we shall show, they are of chalky origin.

In order to fully determine the origin of these limestones the writer has directed a series of experiments in the geological laboratory of the University of Texas. Among these was the making of a series of thin sections and microscopical examinations of the rocks of all the horizons. None of the lower Cretaceous limestones except a few feet of the basal

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[1] Vol. II of the Report of the State Geologist of Arkansas, 1888.

(Trinity) sands showed brecciate or layers in laminate structure, indicative of littoral origin or were accompanied by littoral faunas. All the other lower Cretaceous limestones are of a massive or pasty texture, unlaminated, and of varying hardness and purity, and when microscopically examined show an abundance of foraminiferal remains imbedded in a calcareous (calcite) matrix.

The foraminiferæ always exceeded in number the few molluscan remains, which were seldom found, thus clearly showing that these rocks are of chalky origin.

The rocks of one horizon consist entirely of individuals of the species *Tinoporus texana* of Rœmer, many of which are visible to the naked eye. For this horizon I propose the name of *Tinoporus chalk.*

The excessive metamorphism which these chalks have undergone is due to several causes. In the vicinity of Austin and thence southwest to the Rio Grande, it can be attributed to excessive plication and igneous contacts. This is well shown even where the igneous rocks do not appear at the surface. In some places, however, as at Pilot Knob, southeast of Austin, the chalk of the upper Cretaceous is converted into a crystalline marble along the igneous contacts. In addition to the two great chalk deposits of the upper and lower Cretaceous respectively, there are but three limestone horizons in the entire sedimentation of the two Cretaceous formations of the southwest of other than foraminiferal origin, and they compose but a small fraction of the entire thickness. The lowest of these, as above mentioned, is formed in the basal Trinity beds, and consists of fissile-laminated flags, often composed of shell-breccia, seldom exceeding one foot in thickness.

Analogous laminated limestone layers occur at the base of the upper Cretaceous in the fish bed (Benton) clays. These are the only two laminated (shallow water) limestone horizons in the immense development of the two Cretaceous formations.

The third kind of non-foraminiferal limestones are segregations of calcareous matter, in layers or nodules, mostly in the uppermost arenaceous or glauconitic beds of the upper Cretaceous, as at Ripley, Mississippi, in Coddo creek, near Hearne, Arkansas, or in the Ponderosa marls of the Corsicanna, or Navarro bed, of Texas. These are formed by the lixiviation

and recrystallization of the calcite of the shells imbedded in clays and sands. These beds are always of limited local extent and seldom of economic value. The court houses at Dallas, Texas, and Washington, Arkansas, are partly constructed of this limestone, but in each case the supply was almost exhausted for the building.

Of the total sediments of the lower Cretaceous formation, aggregating over 2000 feet, 1500 feet are limestone (including chalk), all but a hundred feet of which are of foraminiferal or semi-foraminiferal origin. Of the 700 feet of limestone found in the 2100 feet of the upper Cretaceous formation of Texas 600 feet are chalks of foraminiferal origin, while less than 100 feet are of the laminated near-shore, or of segregatory origin.

The sequence of sediments in each of the two formations can be stated as follows:

The lower Cretaceous subsidence began with the deposition of the Trinity sands, which become more and more calcareous towards their top. In these sands are occasional beds of limestone of laminated or shell brecciate structure. As the sea deepened the clays and impure limestones of the basal Fredericksburg were deposited, and these were succeeded by the deeper sea chalks, a thousand feet or more of which were deposited, under conditions so uniform in an ocean so extensive, and during a time so long, that there is as yet no perceptible variation in certain horizons throughout its extent from Arkansas to Mexico. Succeeding this chalky epoch there is an equally extensive deposition of fine greenish clays (the *Exogyra Arietina* clays of Shumard) which may represent a slight elevation of the ocean bottom above the chalk-making depths, for they in turn are covered by another slightly deeper lime deposit, whose continuity was destroyed by the erosion of the inter-Cretaceous land epoch and the upper Cretaceous subsidence. In the upper Cretaceous the transition is from Lower Cross Timber littoral sands (Dakota?) to the deeper Eagle Ford clays, and from these by becoming more and more calcareous to the Austin-Dallas (Niobrara?) chalk, whose 600 feet or more represents another long continued epoch, and from chalk to chalky clays again,—and after a long continued epoch of these clays, which make the Black lands of Texas, to the glauconitic calcareous sand; and

from these to glauconitic sands, the Upper Cretaceous of Arkansas, Alabama and New Jersey. In the light of these facts, based upon investigations in the typical regions of the occurrence of the North American Cretaceous, the two great formations of this country can not be considered of non-chalky origin, as was formerly supposed from studies based upon the uppermost or latest beds of New Jersey and Alabama, but each of them culminates in a great extensive, chalky horizon, gradating into and included between shallower chalk marls,[2] calcareous and glauconitic sands and other more or less shallow water sediments. In other words, in the superb Cretaceous exposures of the Texas-Arkansas region we have recorded in these sediments of the two Cretaceous formations the two subsidences heretofore described, and data for much progressive research in the future, and which when applied to the more disturbed regions to the eastward and westward will be of great assistance in interpreting their structure and history.

EDITORIAL COMMENT.

SOME RECENT WORK UPON THE CRYSTALLINE ROCKS.

Prof. Judd has recently published three papers of considerable geological interest to students of the crystalline rocks. In the Geological Magazine (June 1889) he discusses the question of metamorphism, insisting on the importance of that phase of the subject which he well terms statical metamorphism as distinguished from the dynamical metamorphism of Rosenbusch. By the former term he means the sum of the changes produced in rocks by the included water and gases aided by heat and pressure but without movement. The latter term comprises the effects of these same agents when accompanied with motion. Prof. Judd defines the two classes thus:

1. Dynamical metamorphism includes:—
    - Production of cleavage-structure and jointing.
    - Crushing or deformation of included minerals.
    - "Stretching" of the rocks and production of "mylonitic" bands.
    - Changes of various kinds in the constituent minerals of a rock without loss of identity.

[2] In most of the Rocky Mountain regions and especially in the Trans-Pecos and Eagle Pass regions these calcareous marls and sands are more consolidated, probably in places the result of igneous metamorphism. At Eagle Springs, Texas, and many other places they can be seen capped by a great rhyolitic mass.

Changes of the constituent minerals with loss of identity (transformation) into isomorphic forms with unaltered chemical composition (paramorphism), or with composition altered (metachemism).

Change of the *form* of the rock resulting in the development of granulitic or schistose structure.

Prof. Judd remarks on the wide limits in the alteration of which minerals are susceptible without loss of identity, twin-lamellation, deformation to a system of lower symmetry (as orthoclase to microcline), change of the optic axial angle and plane, either temporary or permanent by heat and pressure, change of color, pleochroism and absorption, of refractive index, sign and intensity of double refraction, specific gravity, hardness and fusibility, and all these without transgressing the limits of specific variation.

The effects of static metamorphism are then discussed. "In these cases the most potent agent by which change is effected is the penetration of the whole mass of the rock by various liquid or gaseous solvents." Orthoclase is chosen as an example. This if formed near the surface assumes the form, &c. of sanidine, if at great depths those of adularia. These under heat and pressure can be further changed as follows:

	Original Form.	
Adularia,		Sanidine,
	passes into	
Anomalous orthoclase,		Common orthoclase,
Microcline,		Opalescent orthoclase,
		Avanturine orthoclase,
		Iridescent orthoclase,
		Murchisonite,
		Perthite;
	and further into	
Zeolites,		Micas,
Epidotes, &c.		Kaolinites, &c.

Yet further in hypocrystalline rocks under the conditions of statical metamorphism the crystalline and stable portion may grow at the expense of the unstable vitreous remainder and many new and remarkable structures may result.

In partial explanation of these remarkable mineral transformations in solid rock Prof. Judd cites the experiments of Guthrie showing that "there is a perfect gradation between the states of fusion and solution;" those of Spring, Van t' Hoff and Reicher proving that pressure can bring the molecules of solid bodies sufficiently close to one another to allow the action of chemical affinity between them which may even continue after the pressure is removed; and also those of Van der Waals

supporting the belief that "all bodies can mix when the pressure exceeds a certain value."

This subject has been developed at greater length in one direction by the same author in the Quarterly Journal for May, 1889, where he describes a singular example of the growth of the felspar crystals (near labradorite) in a porphyritic andesite from Dun da Gu[1] in the island of Mull.

The original crystal was much weathered before its enlargement began so that it exhibited cracks, corroded surfaces, planes of kaolinization and sometimes actual fracture. The added portion and the filling of the cracks show their secondary nature by their behavior under polarized light. "The inner and outer parts do not extinguish simultaneously when the section is rotated between crossed nicols but after the position of extinction of the central core has been passed a dark zone makes its appearance around the central mass and as rotation goes on this dark zone passes slowly and gradually outward through the surrounding fringe."

That the addition was made at the expense of the unstable vitreous matrix is shown by the fact that where two crystals touch one another no enlargement has occurred. The change in the angle of extinction is so gradual and extensive that Prof. Judd says he is led to the conclusion that some of these crystals have a fringe of secondary material which as we pass outward corresponds to every intermediate stage through the andesine and oligoclase series, and sometimes approaches if it does not actually reach the albite limit.

These changes in the constitution of the crystal during its successive stages of enlargement are attributed by the author to the tendency of the more basic minerals to separate from a magma before the more acid ones,whereby the lime is gradually abstracted and the crystal tends to pass from a basic lime-felspar to an acid alkali-felspar or even to quartz.

The sequence of events which in Prof. Judd's opinion has led

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[1] The most enthusiastic admirers of the Gaelic tongue, even Prof. Blackie himself would scarcely recommend it for a universal language on account of the simplicity of its spelling. In the paper quoted Prof. Judd kindly gives his readers a very necessary key to the pronunciation of the names of the places mentioned. Our readers may judge for themselves how necessary is this help.

Dun-da-Gu	is spelled	Dun-da-Ghavithe.
Sarsta Beinn	"	S'Airde Beinn.
Beinn Uaig	"	Beinn-na-Duatharach.

to the development of crystals as above described is the following:

"The labradorite-andesite in which these crystals occur is one of an old series of felstone-lavas belonging to the earliest period of eruption in the Mull volcano. The lava-stream was exposed to weathering and denudation for a long time, sufficient to allow the mechanical injury and partial kaolinization. Subsequently this old lava was buried to the depth of several thousand feet by the later welling out of basaltic and other lavas. The consequence was that the mass was placed in conditions favorable to the development of the felspar crystals They renewed their youth and recommenced growth."

In a third paper also in the Quarterly Journal for May, Prof. Judd put forth some results of a long study of the igneous rocks of the Western Isles of Scotland. Three principal points are insisted on:

1. That the plutonic, holocrystalline rocks of the Western Isles (granites and gabbros) are only the extreme terms of two series which pass by almost imperceptible gradations into the opposite extremes of volcanic pitchstones and tachylites.

2. That the enormous sheets of igneous rocks once covering this area and now indicated only by scattered outliers issued from numerous centers of eruption of which five at least are still recognizable at Mull, Ardnamurchan, Rum, Skye and St. Kilda.

3. That these lava-beds and sheets of crystalline rock of all kinds are entirely of Tertiary age and of subaerial origin.

Some of these conclusions will surprise geologists who have not followed the course of recent petrological investigations. But Prof. Judd's propositions are supported with a mass of evidence that carries conviction. As he says: "The evidence is irresistible that gabbros graduate insensibly into dolerites and dolerites into basalts and basalts into tachylites." The granites also merge insensibly through "granophyric forms into acid lavas and pitchstones."

These gabbros and basalts have been attributed by various writers to earlier dates, such as the Jurassic or even to the Laurentian, chiefly on the evidence of their composition and of their intimate association with the granites whose antiquity was assumed. The whole form "one great contemporaneous series of rocks which as a whole overlies and is

younger than the secondary strata of the district." But in the absence of other evidence such reference was merely "begging the question." How far the appearance and structure of these rocks fall short of determining their age may be inferred from the remark recently made by the director-general of the geological survey of Great Britain that "he is unable to recognize any essential difference of structure or composition between the Tertiary igneous rocks and those of earlier geological age."

During the long process of these eruptions occupying perhaps a great part of the Tertiary era a gradual change in their nature occurred. The early acid ejecta of felstone-forming matter slowly but steadily gave place to basic gabbro-forming outflows. The former were apparently viscous or quick cooling lavas and seldom spread more than ten miles from their focus. The latter cooling more slowly or being more liquid reached a distance of sometimes fifty miles before consolidation occurred.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Solar heat, Gravitation and Sun-spots. By J. H. KEDZIE. Chicago, S. C. Griggs and Co, 1886. 12mo, pp 304, with supplement of 16pp.

This little volume is an astronomical and physical free lance which pierces some of the commonly accepted doctrines or notions concerning the solar system which do not bear the application of keen reasoning. Its thrusts are not by any means limited to prevalent popular notions, but some of the physical doctrines which have been taught by eminent astronomers, and which are found in our common text-books are treated with equal severity. The scope of the book is evinced in its title, and the three parts are treated consecutively, but the treatment and the subject matter so shade off from one part to another that in the philosophical ensemble there are no breaks. The second and third parts are logical portions of a discussion begun in the first part, and the value of the whole, no less than its interest to the reader, culminates in *part three,* in which the author offers a simple but plausible explanation of the existence of sun-spots.

To the geologist the topics and discussions are important, especially to those who inquire into conditions and causes that are not patent to sensible apprehension. The author possesses a fertile scientific imagination, one of the very first qualifications for scientific research and discovery. "In so boundless a field as the universe, where the unknown bears so large a proportion to the known, and the disproof of theories, however grotesque and extravagant, is difficult, the tempta-

tion to allow the imagination to run riot is great. Its value in physical investigations cannot be overestimated, yet it should never be the blind flounderings of an untaught and untamed imagination, but rather the advanced thought of clear minds, guided by known principles, out-running for the time the slower processes of demonstration, but always returning to verify preconceived theories by sound reasoning or actual experiment."

The author hinges his reasoning on three postulates, viz.: (1) Infinite duration of time in the past. (2.) Infinite extension of the universe in space, peopled with suns, worlds, comets and nebulæ. (3.) Conservation of force or energy.

The various prominent theories for the cause of the sun's heat are briefly considered and are severally found to be defective and unsatisfactory, viz:

First, *The conflagration theory*, is untenable because if the universe has existed through past eternity the sun, no matter what his size or material, would have been burnt out, or oxidized millions of ages ago; because, also, it is known that the temperature of the sun is too high for combustion, and because, further, if it were possible to add millions of tons of coal to the sun it would undergo rarefaction instead of condensation, and hence would produce cold rather than heat.

Second, The *meteoric theory* is brought to encounter nine obstacles which are categorically presented. (a) It is unproved. (b) The theory indicates only a temporary provision, since the meteors would all be absorbed in time by our sun and the other suns, and the solar fires would ultimately die out for want of fuel. (c) Owing to the continued increase of the mass of the sun its power of attraction would increase and it would cause the narrowing of the orbits of the planets, so that it would only be a question of time when it would absorb the earth and all the members of our system. (d) Small meteors, moving in regular orbits, according to Newtonian laws, may collide with the earth when in nearly the same plane, but it is an impossibility for them to bolt from their orbits and fall upon the sun. (e) The theory requires the acceptance of the unproved assumption that space through which the sun and solar system are moving is filled with wandering meteors—meteors utterly unlike the minute bodies which are unable to penetrate even our thin atmospheric envelope, but more nearly resembling the moon or the inferior planets in size. If such masses are falling like hail on the sun, they should fall as thick and fast on the earth in proportion to its size, and then the earth would become as hot as the sun, and would be in danger of being dislodged from her orbit. (f) The effect of a collision of a meteor with the sun can only be judged by comparison with such collisions with the earth. Hence the collision of a non-elastic meteor with the elastic gaseous envelope of the sun might, by the arrested motion, develope heat enough to raise the cold mass of the meteor to the same temperature as that of the sun, and the temperature of the sun would neither be increased nor di-

minished—there would be only an infinitesimal change in the sun's path. "Only in the improbable event of the meteor's developing more heat than would be necessary to raise its own temperature to an equality with that of the sun, could it increase the sun's temperature." (g) These bodies which are assumed to be continually falling on the sun either float idly in space or belong to some system. They cannot belong to our system because it would be impossible for them to leave their orbits. Then to what system? Could any other sun control them within the limits of our sun's force of gravitation? And as to their floating idly in space it would be time wasted to point out the many absurdities it would involve. (h) Our sense of permanence in the order of nature,and faith in the constancy of the sun,is not consistent with the idea that such constancy depends on the fortuitous meeting of exactly the right number of meteors of exactly the right velocity and size, daily, with the sun.

Third, The *condensation or shrinkage theory*, by which it is supposed the sun's heat is due to his "flagellating himself by the descent upon himself of parts of himself," not only has the defect of making the sun and by analogy all suns, machines which when once wound up are allowed to run down hopelessly by enormous emanations given out but never returned: but also is self-destructive in that, necessarily, the heat that may be produced by the supposed shrinkage would cause at once an equal expansion and there would be no contraction, and no heat resultant. But the heat emanations from the sun are sufficient to heat two billions two hundred million worlds equal to the earth; such a loss, unless suplied *ab extra*, would cause an appalling rate of cooling and condensation which would become visible even within the time since man became an astronomical animal. For five thousand years his light and heat have undergone no perceptible diminution.

Fourth, The *theory of potential energy*, which, while allowing that the energy of the sun is being gradually dissipated by radiation, yet asserts that "the potential energy of the solar system is so enormous, approaching in fact, possibly to what we in our helplessness call infinite that it may supply for absolutely incalculable future ages what is required for the physical existence of life." We know of no great storehouse of potential energy. This theory assumes it but does not inform us where it resides. The unoxidized matter existing in the sun is already too far heated to allow of combustion.

Fifth, The *theory of atmospheric condensation*, which is that of W. Matthieu Williams, is summarized by Mr. Kedzie in three propositions. 1. "That there is a universal atmosphere. 2. That the sun is constantly (if I may be pardoned the colloquialism) butting against this atmosphere at the rate of 450,000 miles per day. 3. That the compression produced by the sun's impact evolves the heat of the sun. He also deals largely in the rollings, tossings, explosions, dashings, clashings and flashings of the alternating combining and decomposing gases in the sun's atmosphere." To this the author brings the following

objections: If any chemical changes at all take place in the sun's atmosphere (possibly in the outer atmosphere) they result in more condensed substances which on settling toward the sun are again decomposed by the increased temperature, and the heat generated by the chemical combination is re-absorbed by the decomposition, and there is no resultant general increment of heat in the sun. Again, as to the heat generated by the sun's impact on a supposed universal atmosphere, and its being the supply for the heat it radiates into space. Mr. Kedzie introduces, after his manner, a quaint but sufficiently conclusive illustration, which, to give the reader an idea of the familiar and commonplace reasoning that characterizes the book, it will be well to quote entire. "Imagine a concave mirror large enough to enclose the sun and his proper atmosphere,—for according to Mr. Williams the sun has an atmosphere of its own. Suppose this mirror to reflect back to the sun every ray of heat radiated by him as well as exclude every ray approaching him from without, the sun's heat would of course remain absolutely unchanged. We ignore, for the present, any supposed supply of heat by contraction of the sun. Mr. Williams ignores this source entirely. Now open the windows of this hollow sphere, both behind and before the advancing sun. This hypothetical universal atmosphere would of course rush in, and an equal quantity of the sun's atmosphere proper would rush out of the windows in the rear. Would this process heat or cool the sun? That would depend wholly on whether the atmosphere of space is hotter or colder than that of the sun. It requires no prophet to predict the result. It is believed by all that the atmosphere of space, if such exists, is intensely cold. Remove the imaginary hollow sphere entirely, and give the winds full sweep on all sides, and the blazing atmosphere of the sun would simply be swept away and its place supplied by one colder than the blasts that play around the north pole in midwinter." Other equally strong points are made against this theory.

Sixth. *Dr. C. W. Sieman's new theory* supposes the exhaustless energy of the sun to be sustained by a grand endless circulation. This consists of the emanation of certain compounds, mostly in a gaseous condition, from the equatorial regions of the sun into space. These reach even beyond the orbit of the earth. In the interstellar spaces these compounds are rarified and decomposed, returning to their elementary condition. But they are, in this condition, precipitated again upon the polar regions of the sun, where, by recombustion, they give out the heat which supplies the sun in perpetuity. Flowing toward the equator they are again projected from the sun, in a ceaseless round. Mr. Kedzie accords this theory the merit of not violating the theory of the conservation of force. It does not require, as nearly all others do, the radiation and loss in space of the vast energy of the sun. Still he notes the following objections: (a) The existence of an interstellar resisting medium, or universal atmosphere, other than ether, is not yet proved, to the satisfaction of scientists. (b) The dissociation

of chemical elements once compounded, requires more heat than the interstellar spaces possess. Attenuation may favor such decomposition, but the requisite degree of heat is totally wanting. (c) The degree of heat in the sun is too great to allow the chemical association of the gases that this theory supposes are continually falling upon its polar regions. The falling gases would cool the sun rather than heat it. (d) The chemical composition at the poles, supposed by this theory, evolves, of course, exactly the same amount of heat as that required for the decomposition of the same substances on their equatorial flight from the sun, and thus adds no heat to the sun, and hence can not supply the enormous radiation, to account for which is *the problem* to be solved. (e) "If the vigorous logic of mathematics would admit of matter being without weight, or even weighing less than nothing at the sun's equator, so that it would actually leave the sun for extended journeys through space, this condition would apply to all the equatorial matter of the sun, and, through this, to the whole body, which is generally regarded as gaseous. We should then have the sun himself going abroad in search of fuel to maintain the solar fires." (f) According to the reasoning of R. A. Proctor (*Eclectic*, July, 1882) "there is not the slightest possibility of matter being projected into space from the sun's surface by centrifugal tendency," yet this tendency for gaseous compounds is the corner stone of Dr. Sieman's ingenious theory.

Seventh. *Thompson's theory of convection currents.* This postulates an internal circulation in the fluid of which the sun is supposed to consist, through which it is kept of nearly uniform temperature constantly. The cooled or partially cooled surface is immediately replenished by currents from within bringing fresh supplies of heat. This does not profess to supply an indefinite amount of heat, but allows of the loss of all radiated heat. It depends on the vastness of the heated sun, to furnish heat for so long a period that to our apprehension the slowness of the change is such that the change is not perceptible. This must fail if either of the following propositions be true. 1st. If we have sufficient evidence on which to decide that the sun is not cooling at all. 2nd. If the heat given out by the sun is out of all proportion to the gradual cooling supposed by this theory. The author then considers each of these propositions under the caption, *Enormous amount of heat emitted by the sun*, and shows conclusively, by quotations from Dr. J. R. Mayer, Prof. Young and Prof. Langley, not only that the radiation is enormous but that it is so vast that it would certainly be perceptible, without having a replenishment, within the 5,000 years that the sun's heat has been observed, amounting to 9,000 degrees centigrade. This destroys the theory, since it establishes the second proposition and strongly fortifies the first.

THE AUTHOR'S THEORY OF SOLAR HEAT.

Having shown the inadequacy of the principal existing theories the author considers himself justified in offering another. "If the theories examined are as unsatisfactory to the reader as to the writer, there

remains only an aching void for a new one, which it would be unkind to withhold, since the material is so abundant, being in most cases 'such stuff as dreams are made of,' and yet in our day dreams we sometimes catch glimpses of thoughts that lead us into the very presence of truth."

The new theory of the author starts with a further postulate, viz: light and heat are essential elements of the universe, and their existence is not to be explained nor called in question. They are convertible into all other forms of energy, but they cannot be lost. They cannot wander beyond the confines of the universe, for this is boundless. The real problem is,How are the light and heat given out by the sun,or an equivalent for the same, reconcentrated in that luminary?

Briefly stated the author's theory assumes heat as the primal, unspecialized, essential condition of universal matter, matter also unspecialized and nebular. All other forms of energy are modified conditions of heat. Heat is converted into light, motions of various kinds, chemical affinity, electricity, and even vital energy. Heat as such is constantly dying out, but it dies as the seed does on being committed to the ground, to reappear in new and wonderful forms. Heat that leaves the sun, and without doubt also other suns that inhabit space, traveling on the vibrations of the all-embracing ether, cannot dwindle into non-existence because if it did the grandest discovery of modern times, the conservation of force, disappears with it. What becomes of it? The author conceives of it as lurking as other forms of force in every part of the universe, changed by circumstances sometimes to mechanical force (or gravitation), stored up in chemical compounds, or developed into electricity, magnetism, or vital energy. It is thus not lost. It returns to the sun specialized as mechanical force, electricity, etc. "He sends it forth again in the general unsifted form of radiant light and heat." The etheral ocean is full of the undulations of heat, or the elements of heat, passing in all directions from sun to planet and to distant suns. The suns supply the ether, and the ether supplies the suns. "Since the dawn of creation heat has been undergoing transformations and retransformations, but neither annihilation nor re-creation." It is diffused in all directions, as well toward the suns as from them.

[TO BE CONTINUED.]

Les geologues et la geologie du Jura, jusqu'en 1870. Par JULES MARCOU. (Ext. des Mem. de la Soc. d'Emulation du Jura, 1889. These memoirs, comprising only the creative period of the geology of the Jura, extend only to the year 1870. They detail some of the personal labors and intercourse of M. Marcou with Dr. Germain, Pidancet, Thurmann, Pictet, Dr. William Roux, Agassix, Fraas, Lory and others; specifying the various advances in the knowledge of the Jura wrought out by their joint labor. It also contains a chronologic review of the earliest geological work on the same, beginning with that of Charbaut in 1818.

First report on the Iron mines and Iron ore districts in the state of New

York. By JOHN C. SMOCK, (Bul. N. Y. State Mus. No. 7, June, 1899, Albany). In the paleontologic and stratigraphic geology of the state, New York has taken the lead of all the States of the Union; but in keeping the world acquainted with her natural resources, so far as they spring from the rocks, she has been as markedly delinquent. In some of the annual reports of the original survey of the state, and also in the final quarto volumes, particularly those of Emmons, Beck and Mather, the claims of economic geology were kept in view, and very important descriptions and records were then put in print which not only show their appreciation of the final, as well as of the first and principal, object of such a survey, but present the strongest contrast with the reports of those who confined their work entirely to the higher and technical scientific questions of geology. For a long period of years there has been no advance in economic geology in New York through any public effort. Paleontology has been prosecuted by the persistent, and now successful efforts of Prof. Hall, till now it may be said that among commonwealths New York stands alone, as an example, not only to other states of the Unions, conspicuous among her equals, but to the States of longer history across the ocean, in the service she has rendered to natural science.

It is highly gratifying that, through the efforts of Prof. Smock, a new departure has been begun at Albany, and that the geologic questions that concern the direct products of the rocks, so far as they are employed for the comfort and convenience of man, are being inquired into and reported to the Legislature.

This is the second report of this kind that Prof. Smock has made, the former being on the building stones of New York. This on the ores of the state is not final. Many other things are involved in a knowledge of the iron ores—questions of their mineralogical and geological relations, their origin, their kinds, their impurities and their comparitive value in the furnaces of the iron-monger. Prof. Smock has given a sketch of their distribution and some history of each mine and its products. The work is well begun, but it will be a work of years before he will be able to report as thoroughly as he should, and equally with the detail that the State of New York has carried forward in the paleontology of the state.

Fossil fishes and fossil plants of the Triassic rocks of New Jersey and the Connecticut valley. By JOHN S. NEWBERRY, 1888. 4to, XIV, 152 pp. 26 pl. $1.00 (U. S, Geol. Sur. Mon. vol. XIV. Washington). This memoir mentions twenty-eight species of fish appertaining to the Triassic of the Atlantic border of North America in strata distributed from Nova Scotia to North Carolina, thirteen of them being new. The others had been named principally by Redfield, but a few also by Newberry, Egerton and Agassiz. Of plants, seventeen species are mentioned of which five are by Newberry, and the others by Rogers, Schimper, Brogniart, Endlich, Emmons, Saporta, Fontaine and Fr. Braun. The *geological sketch,* which forms the first part of the volume,

embraces a valuable brief summary of the geology of the Triassic in the eastern part of the United States, but has important correlative allusion to that of the central area. From this the following points are taken.

(1) The measures are generally red, and non-fossiliferous, but in the Connecticut area include some dark shale charged with carbonaceous matter and fossil remains. Dark and dove-colored shales in New Jersey also contain fish remains, exhaling a bituminous odor when struck with a hammer. In general the principle is stated that the general red color in these rocks indicates the absence of organic matter at the time of their formation; "for where decaying organic matter is present in any considerable quantity it reduces the peroxide of iron to protoxide, and makes the color, so far as influenced by the salts of iron, gray, green or blue. Where the organic matter is in very large quantity it imparts the characteristic color of carbon, and makes the shale or limestone which contains it black.

(2) The plant-bearing beds are the equivalent of the Keuper (Rhætic) or upper Trias, as formerly claimed by Hitchcock, Emmons, Marcou and Bunbury, this determination being based mainly on the researches of Fontaine. Emmons and Marcou, however, believe the lower beds to be Permian.

(3) The Triassic strata underlying the Indian Territory, northern Texas, New Mexico, etc., originally extended to the Wasatch mountains which formed the western shore of the sea in which they were deposited, but are mainly without fossils.

(4) Yet from three localities fossils have been found in them, viz: San José, New Mexico, the old copper mines above Abiquiu, and Los Bronces, on the Yaki river, in Sonora. "At the first mentioned locality are found *Walchia* and *Calamites* below, which mean Permian, and in softer beds of sandstone above—doubtless Triassic—impressions of fern fronds too indistinct for determination."

(5) The fossil plants in these western localities go far to prove that the Atlantic and western Triassic beds are in the uppermost division of the system.

(6) The beds containing Jurassic fossils in Utah, Colorado and Wyoming wedge out toward the south, allowing the Dakota group of the Cretaceous to rest on the upper member of the Trias.

On the Tertiary and Cretaceous strata of the Tuscaloosa, Tombigbee and Alabama rivers. By EUGENE A. SMITH and LAWRENCE C. JOHNSON. Bul. No. 43, U. S. Geol. Sur. 1888.

In the summer of 1883 a steamboat trip of two weeks duration was made from Tuscaloosa down the Tombigbee river to its confluence with the Alabama, and up the latter river to Prairie Bluff, by Dr. Eugene A. Smith, of the Alabama Geological Survey and Mr. L. C. Johnson of the U. S. Geological Survey, at the joint expense of the two surveys. The results of the observations made on this two weeks' trip were written up by Dr. Smith as a Bulletin, to be published by the U. S. Survey. This first report which embodied all that was done by the two Surveys jointly, and, with the exception of some observations made by Mr. Johnson in Wilcox county, to all which the joint authorship applies, was so imperfect and full of gaps, that, at the request of Dr. Smith, its publication was delayed until fuller imformation could be obtained. Accordingly in the summer seasons of 1884-5 and 1886 the whole ground was re-examined by Dr. Smith and his assistants on the Alabama Sur-

vey, and observations were extended over all the adjoining country, and the proper relations of the river sections were carefully made out, photographs for the illustrations were taken, and the whole Tertiary and Cretaceous sections were carefully made out and verified. Results of the work done by the Alabama survey during 1880 and 1881 and 1882 were incorporated, so that the present bulletin represents, in addition to the two weeks' joint work of the two surveys, the results of six seasons' summer work of the Alabama Survey alone. It is this later work of the Alabama Survey which gives the Bulletin most of its value, and has changed it from a very imperfect sketch, to a fairly complete and trustworthy section of all the strata of Cretaceous and Tertiary age appearing in the vicinity of the two rivers.

Prof. Tuomey in 1856, coming from the fields of South Carolina, found in Alabama the series of rocks identical with those which, in South Carolina under the name of Buhrstone, were at the base of the Tertiary formation. He accordingly considered the Buhrstone as the basal rocks of the Alabama Tertiary also. In 1872, Dr. Smith made his first excursion into this territory and found that there were many feet of strata underlying the Buhrstone. This conclusion was communicated to Prof. Heilprin, to whom Dr Smith sent a number of new shells from one of the sub-Buhrstone beds, at Wood's Bluff. Descriptions of the new species and a diagram showing, from Dr. Smith's notes, the relations of the Wood's Bluff strata to the Buhrstone, were published by Prof. Heilprin in 1880 and 1881.

These papers of Prof. Heilprin, and his *Tertiary Geology*, contain all that was published upon Alabama Tertiary from the time of Prof. Tuomey up to the publication of the present Bulletin, except the papers called forth by the curious articles of Otto Meyer, in which the attempt was made to throw doubt upon the work of other geologists in this field, and to obscure what has long been perfectly well established in regard to the stratigraphy of parts of the southern Tertiary.

The work now under consideration gives the following table of the Tertiary and Cretaceous strata of Alabama, with the thickness of each:

Tertiary (Eocene)	Upper, White Limestone,	Coral Limestone (Vicksb'g?)	150
		Orbitoidal " (Vicksb'g)	140
		Jackson,	60
	Middle,	Claiborne,	140-145
		Buhrstone,	300
	Lower, Lignitic,	Hatchetigbee	175
		Wood's Bluff	80-85
		Bell's Landing	140
		Nanafalia	200
		Matthews' Landing and Nahcola	130-150
		Black Bluff	100
		Midway	25
Cretaceous,		Ripley	250-275
		Rotten Limestone	1000
		Eutaw	300
Cretaceous (?)		Tuscaloosa	(?)1000

The most important additions to our knowledge of Tertiary and Cretaceous geology given in the present work are the carefully meas-

ured thicknesses of the various strata, the working out of the sub-Buhrstone strata of the Tertiary, and the finding of a great series of sandy and clayey beds below the hitherto lowest of the Cretaceous, and the discovery and description of the various undulations and faults in both Cretaceous and Tertiary strata.

1. The whole thickness of the Tertiary along these two rivers is between 1629 and 1700 feet, of which more than 1000 feet lie below the Buhrstone, heretofore considered the base of the Tertiary in Alabama, (though not in Mississippi). The thickness of the Cretaceous is over 2500 feet, of which 1000 feet belong to the Rotten Limestone, and 1000 to the newly named "Tuscaloosa" group.

2. The beds underlying the Buhrstone consist of laminated sands with clay partings, clayey sands, lignite and beds of marine shells. The shell beds have been used to define the different horizons of this part of the Tertiary and seven such divisions are recognized and described, each possessing some very characteristic features and impressing itself very markedly upon the soils and the topography of the country along its line of outcrop.

3. A great series of sands and clays, containing, in places, many beautiful leaf impressions has been found to occupy, in Alabama, the base of the Cretaceous formation. At the time the bulletin was printed, the age of these beds was not quite definitely made out, but recently Prof. Fontaine has collected in this territory, and has no hesitation in calling the beds which hold the plant remains, Cretaceous. As yet no animal remains have been discovered in these beds in Alabama, which appear to be identical in age and in most of their physical and lithological characters with part of the Potomac formation of the states further north and east.

4. Evidences of the disturbance in the Tertiary of the Tombigbee river were long ago noticed by Prof. Tuomey. Dr. Smith has found that there are two well marked anticlinal folds in the Tertiary, the Hatchetigbee and the Lower Peach Tree folds, and one fault, the Bethel fault, with at least 200 feet displacement. It is also shown that the strata do not lie in other respects in undisturbed position, for there are everywhere very considerable undulations along the direction of the strike of the beds.

Again in the upper beds of the Cretaceous, there are numerous faultings and undulations, clearly shown in the diagram of the river bank below Moscow on the Tombigbee.

Since the publication of this report Dr. Smith has carried his observations of these beds eastward to the Georgia line, and has discovered many interesting variations in the characters and thickness of the various strata in that direction. These observations will soon be published in a report of the Alabama geological survey.

The report is illustrated by a map (with *unusual* colors), by a number of views taken from photographs, and by a great number of carefully drawn vertical sections of actual exposures along the banks or

in the near vicinity of the two rivers, which show, when taken together, an uninterrupted and continuous view of the succession of the strata from the White Limestone at the top of the Tertiary down at least to the Tuscaloosa group of the Cretaceous.

The report also contains a full account of the bibilography of the lower Cretaceous formations of North America, by Mr. W J. McGee.

RECENT PUBLICATIONS.

1. *State and government publications.*

Fossil Fishes and Fossil Plants of the Triassic rocks of New Jersey and the Connecticut valley. 1888. By J. S. Newberry. *U. S. Geol. Survey, Monograph xiv.* Washington, 1888. 4to, pp. 95. Plates 26.

Annual report, Geological Survey of Arkansas, 1888, vol. III. The geology of the coal regions; a preliminary report upon a portion of the coal regions of Arkansas. By Arthur Winslow, assistant geologist in charge. x, 122 pp., 8vo, one map; Little Rock.

2. *Proceedings of scientific societies.*

Remarks upon sedimentation in the Cincinnati group. By Jos. F. James. *Bul. Cin. Soc. Nat. Hist.* vol. XII. No. 1. April, 1889.

Notes on the geological relations and mode of occurrence of some of the more important economic minerals of eastern Quebec. By. R. W. Ells. *Trans. Ottawa Field Club,* vol. III. No. 2. Aug. 1889.

3. *Papers in scientific journals.*

Amer. Jour. Sci. July No. A new Erian (Devonian) plant allied to Cordaites, SIR WM. DAWSON. Stratigraphical position of the Olenellus Fauna in North America and Europe. C. D. WALCOTT. Notes on the occurence of Rock in the Absaroka range, Wyoming territory. A. HAGUE. On Allotropic Forms of Silver. M. CAREY LEA. The Peridotite of Pike county, Ark. J. C. BRANNER and R. N. BRACKETT. Pl. I. On Prevailing Misconceptions regarding the Evidence which we ought to expect of former Glacial Periods. J. CROLL. Mineralogical Notes on Fluorite, Opal, Amber and Diamond. G. F. KUNZ. Discovery of Cretaceous Mammalia. O. C. MARSH. Plates II. to V.

Aug. No. Earlier Cretaceous rocks of the northwestern portion of the dominion of Canada. GEO. M. DAWSON. Certain Porphyrite Bosses in northwestern New Jersey. J. F. KEMP. Great lava flows and intrusive trap sheets of the Newark system in New Jersey. NELSON H. DARTON. Recent Explorations in the Wappinger valley Limestones and other Formations of Dutchess Co., N. Y. W. B. DWIGHT. Pl. VI. Notice of Gigantic Horned Dinosauria, from the Cretaceous. O. C. MARSH. Discovery of Cretaceous Mammalia. O. C. MARSH. Pls. VII. and VIII. Silicic acids. GEO. F. BECKER.

PERSONAL AND SCIENTIFIC NEWS.

Henry William Bristow, F.R.S. died June 14 at the age of seventy-two. As early as 1842 he was a member of the staff of the Geological Survey of the United Kingdom. He was the author of various works on geology and mineralogy; he wrote the mineralogical articles in Brande's "Dictionary of Science, Literature and Art" and the articles on minerals and rocks in Ure's "Dictionary of Arts, Manufactures and Mines." He was the recipient of honors from several geological societies and from some of the crowned heads of Europe.

Natural Science in the Davenport Schools. From the very inception of the Davenport Academy of Sciences the chief object has been the advancement of the public interest in natural science, especially to secure the most intimate practicable co-operation, with the educational system of the city, state, and country. To this end it has been the constant effort on the part of the Academy to encourage visits of classes and teachers with a view of illustrating the subjects at its rooms and of promoting the introduction of natural science in the school work.

Recently the Academy devised the plan of a series of visits by the several classes of the public schools consecutively throughout the year to the rooms of the Academy, under the charge of their teachers in each instance, for an illustrated lesson on some subject in natural science, the same being continued from day to day until all the classes had received this lesson in their turn.

In the city of New York Prof. Bickmore has been successful in interesting the authorities of the public schools in the American Museum of Natural History, at Central Park, and the teachers in the public schools are not only allowed free admittance to the collections, but regular lectures are given at the museum throughout the year intended especially for the qualification of teachers to give instruction in natural science. These courses of lectures are largely attended, and have more recently extended to other city schools in New York state. With this exception the Davenport Academy is so far as we know, the pioneer scientific institution in this country to suggest and execute a plan for thus utilizing its museum and collections of specimens in natural history, in direct connection with the public school, and it seems to open the door to a wide range of usefulness for such institutions, and to render such collections of a hundred fold more interest, value and direct benefit to the community.

An Immense Deposit of Ice, thought to have its date from the glacial period, has been found in Pine Creek cañon, Idaho, and capitalists are considering the feasibility of mining it for commercial purposes.

THE

AMERICAN GEOLOGIST

VOL. IV. OCTOBER, 1889. No. 4

THE SUBGENERIC GROUPS OF NATICOPSIS.

BY CHARLES R. KEYES.

The described species of Naticidæ from the American palæozoic rocks number about three score. These have commonly been referred to the genera *Naticopsis*, *Platystoma* and *Strophostylus*. The first of these three terms was proposed in 1844 by McCoy,[1] and included shells which had previously been assigned to the modern genus *Natica*. Seven species were enumerated under the new title; but of the accompanying figures only two showed the apertural characters. In America the shells of this group were first recognized by Norwood and Pratten,[2] who described from the Coal Measures, *Natica ventricosa*. Shortly afterward several other forms were detected and placed under the same genus. It was then found that McCoy's generic term was applicable to the American forms hitherto regarded as *Naticæ*. And it has recently been discovered that in addition to the species generally recognized as belonging to *Naticopsis*, the genus should also include several other forms now known under other generic titles.

The species that have been referred to *Naticopsis* appear to

[1] Syn. Carb. Foss. Ireland, p. 33.
[2] Jour. Acad. Nat. Sci., Phila., 1855.

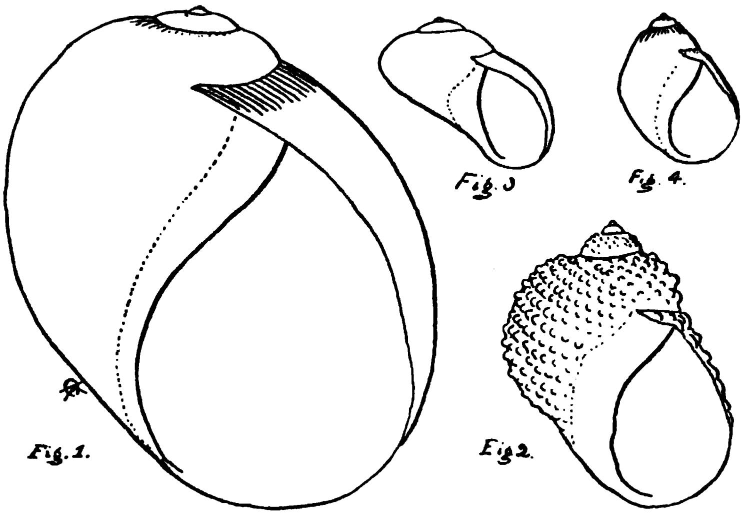
form at least two and possibly three more or less well defined groups. These sections differ so greatly in several important particulars that actually they should be regarded as generically distinct. Meek and Worthen[3], recognizing the fact, proposed to establish three subgenera; but their subdivisions were based upon surface ornamentation. The three sections were: *Naticopsis* proper; a group typified by *Nerita subcostata* Goldfuss, but not named; and *Trachydomia*, including *N. nodosa*, M. & W., *N. hollidayi* M. & W. and *Littorina wheeleri* Swallow; besides two European species. In *Naticopsis* proper, as represented by the typical forms, and by the majority of American species referred to the genus, the shells are relatively thin; the spire very short; the outer lip extremely thin and sharp; the inner lip also thin and slightly depressed; the last volutions generally more or less distinctly flattened or concave on the upper half and marked towards the suture by numerous small, short, equidistant costæ parallel to the lines of growth; the surface otherwise glabrate. In contradistinction the shells of *Trachydomia* are massive, with the spire larger and more elevated; the outer lip very thick, but abruptly becoming sharp; the columella very heavy, the calosity thick and greatly extended; the volutions shallowly channeled along the suture; and the surface covered with numerous small equidistant nodes. A single North American species—*Littorina wheeleri* Swallow—seems to be referable to *Trachydomia;* the other three forms described under the genus *T. nodosa* M. & W., *T. hollidayi* M. & W. and *T. nodulosa* Worthen being at present regarded merely as more mature individuals of Swallow's species. A comparison of an extensive series shows that within certain limits the shells of this group are quite variable. The calosity in some specimens is much more extended than in others; while numerically the surface nodes vary greatly in different individuals, and become much larger and more widely separated as, with age, the shell increases in size.

Another group closely allied to *Naticopsis* is *Isonema;* the type of which now appears to belong to the former genus. As originally established by Meek and Worthen[4] it was regarded as a subdivision of *Holopea;* and had for its characteristic spe-

[3] Geol. Surv. Ill., vol. II, p. 364. 1866.

[4] Proc. Acad. Nat. Sci., Phila., 1866, p. 251.

cies *H.* (*Isonema*) *depressa* M. & W. *Loxonema bellulata* Hall was also included; and later Meek[5] added another congeneric form—*Isonema humilis.* In 1873 Hall and Whitfield[6] figured *I. humilis* as *Naticopsis lævis* Meek; the specimen, however, was very perfect and exhibited all the generic features much more clearly than the type of *Isonema.* Subsequently Meek,[7] redefining his *I. humilis* placed both this species and *I. depressa* subgenerically under *Naticopsis.* Six years later Hall[8] made *Loxonema bellulata*[*Isonema bellulata* (Hall) M. & W.] the type of a new genus—*Callonema,* which also embraced two additional forms—one originally described as a *Pleurotomaria* and the other as a *Platystoma.* *Callonema* as thus understood bears only a slight superficial resemblance to the palæozoic Naticidæ, and probably does not belong to this family. The two forms that constitute the "Isonema" group are slightly more depressed than the shells of *Naticopsis* generally; and have the small costæ that extend a short distance from the sutural line, more lengthened



Explanation of figures.—Fig. 1. *Naticopsis phillipsi* McCoy. Fig. 2. *Trachydomia wheeleri* Swallow, enlarged two diameters. Fig. 3. *Naticopsis ventricosa* N. & P. Fig. 4. *N.* (*Isonema*) *humilis* Meek.

[5] Proc. Acad. Nat. Sci., Phila., 1871, p. 79.
[6] 23rd Rept. State Cab. N. Y., pl. xii.
[7] Palæ. Ohio, vol. i, p. 214.
[8] Palæ. N. Y., vol. ii, p. 50.

than is usually the case. In all other respects the characters appear to agree very well with those of McCoy's genus.

In America there are probably about a dozen valid species of *Naticopsis*, the others described as such being identical with forms previously known. *Natica littonana* Hall from the Warsaw limestone apparently belongs to the globose group of *Soleniscus* and therefore will stand as *S. littonanus*. *Isonema depressa* M. & W. as finally written by Meek himself, *Naticopsis* (*Isonema*) *depressa*, was preoccupied by Winchell for a Kinderhook form; and it is proposed to substitute the name *Naticopsis linearis*.

VIEWS ON PRENEBULAR CONDITIONS.

BY ALEXANDER WINCHELL.

Geologists interested in the speculative departments of their science will be gratified to know the state of opinion concerning the earliest condition of terrestrial matter on which deductive reasoning sheds any light. That the matter of our planet, in common with that of the Solar System has undergone a physical evolution of the nature first outlined by Kant, in 1755, is now almost universally believed by those who have based their opinions on a rational examination of the evidences. In addition to the familiar proofs, we may mention the new and original elucidations of M. Roche, so highly esteemed by professor Darwin, and the very remarkable photograph of the planetary nebula in Andromeda exhibited to the Royal Astronomical Society, on December 6, 1888. This is regarded by professor G. H. Darwin as affording "something like a proof of the substantial truth of the nebular hypothesis."[1] With reference to the same photograph Dr. Huggins remarks, "The stage of evolution which the nebula in Andromeda represents is no longer a matter of hypothesis. The splendid photograph recently taken by Mr. Roberts[2] of the nebula, shows a planetary system at a somewhat advanced stage of evolution; already several planets have been thrown off, and the central gaseous mass has condensed to a moderate size as

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[1]Darwin, *Phil. Trans*. Nov. 15, 1888. Note added Dec. 19, 1888. An excellent engraving from this photograph was published in *Knowledge*, Feb. 1, 1889, and another on a larger scale Aug. 1889. Both reveal an annulated structure in the accompanying smaller nebulæ (Added Sep. 7, 1889.

[2]Monthly Notices, Royal Astronomical Society.

compared with the dimensions it must have possessed before any planets had been formed.[3]

The nebulæ have long been suspected to belong to the order of cosmic existence which served as the starting point of those rotations, annulations and planetations which marked the history of our system. The constitution of the nebulæ and their antecedent history, have, however, been involved in great mystery. The irresolvable nebulæ—to which the present reference is restricted—have been generally conceived to consist of tenuous matter heated to luminosity. Whether in the condition of a luminous gas, or that of a firemist, or that of the rings of Saturn and the matter of the zodiacal light, remained a question. The publication, in 1864, of Mr. Huggins' results of spectroscopic studies of certain nebulæ,[4] seemed to demonstrate that at least some of the luminous matter of certain nebulæ exists in the condition of a gas. Hydrogen, it was thought, was quite certainly identified, while the brightest line in the spectrum was exceedingly close to nitrogen.[5] Huggins' later researches throw doubt on the identification of nitrogen, and tend to suggest the presence of lead.[6]

While making this brief reference to elementary matters indicated in the nebulæ, it may be stated that Mr. Lockyer, in a paper read before the Royal Society in 1887,[7] stated that only seven lines in all had been recorded to that time in the spectra of the nebulæ, three of which coincide with lines in the spectrum of hydrogen, and three correspond to lines in magnesium. Dr. Huggins, in his late memoir, has made a very critical examination of the claims of magnesium for recognition in the nebulæ and concludes, against Mr. Lockyer, that the coincidence of the lines is not sufficiently exact.

Aside from the identification of substances, the recognition of gaseous states of very high temperatures is considered es-

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[3]Huggins, Memoir read before the Royal Society, May 2, 1889. A beautiful delineation of the nebula of Andromeda is given by Father Secchi in *Le Soleil*, VOL. II., PL. J. Fig. 2. He remarks, "One circumstance deserves to arrest our attention. Certain planetary nebulæ seem to offer luminous points. * * * Meantime the planetary nebula of Andromeda presents two spectra superposed" p. 464.

[4]"On the spectra of some of the Nebulæ." *Phil. Trans.*, 1864.

[5]"On the Spectrum of the Great Nebula in Orion," etc. *Proc. Roy. Soc.* VOL. XX. See the results summarized by Le Padre Secchi, "Le Soleil," vol. II. pp. 461-466.

[6]In a memoir read before the Royal Society May 2, 1889.

[7]*Roy. Soc. Proc.* vol XLIII. p. 111.

tablished. Huggins, Lockyer and others believe that some of the matter exists in a state of dissociation. At the same time, some of the nebulæ, notably that in Orion, present also, a continuous spectrum, as if matter existed in them in a condition different from gaseity, though Huggins cautiously suggests that under most favorable conditions the continuous spectrum may be found to consist of bright lines. The evidence as observed, however, is in accord with the presumption which may be offered on other grounds, that matter may exist, in aggregations as vast as the nebulæ, in all conceivable conditions—dissociated, gaseous, liquid, and solid; luminous and non-luminous.

We once felt that in tracing the genealogy of our system to the nebulous condition of matter, we had attained what might fairly be denominated a beginning. But as the nebular theory becomes less speculative, the speculative spirit is tempting science to inquiries about *pre-nebular* conditions. If matter was not created in nebulæ, they have had an antecedent history which it remains to disclose by observation and reasoning. If the data of science enable us to reason out antecedent conditions along a line of evolution, then we may rest in the sure conviction that the nebula itself represents only an ulterior stage. Matter was not originated in nebulæ.

The discovery of the cosmic nature of meteorites through the researches of Newton, Schiaparelli, Oppolzer and others; the establishment of the existence of meteoroidal swarms revolving in orbits about the sun; and especially the identification of the August and November swarms with certain comets[9] furnished indications that comets generally are constituted of masses of matter analogous to those which reach the earth as meteorites. The present writer, as early as 1877, generalizing from the recognized facts of meteorites, announced in a public lecture reported in the daily papers of various cities, his theory of the universality of "cosmical dust," and its slow aggregation into cometary and nebular masses.[10] In a subsequent

[9]The writer has given an elementary exposition of this chapter of science in "World-life," pp. 3-23.

[10]It is stated by Mr. Lockyer, that a similar theory was published by Prof. Tait in "Good Words"; but of that the writer had no knowledge. The coincidence of views, if it exists, must be regarded as lending confirmation to the theory. The late professor R. A. Proctor (in "Other Worlds than Ours," 1870) conceived of the growth of cosmic bodies "under the continued rain of meteoric matter;" but his purpose was

work, he explained with considerable detail, his conception of the mode of aggregation of "cosmical dust" into nebular and cometary assemblages.[11] In this he spoke in particular of the necessary collisions of constituent parts, the development of intense heat, and the formation of an elongated train, in the case of comets moving within the Solar System.[12]

This theory of the origin and constitution of comets has been heartily endorsed, and discussed with ample learning, in a series of papers published by Prof. Lockyer, in Nature, in volumes XXXVII, XXXVIII, XXXIX, but more specifically in the latter volume. Here (page 402), he mentions professor Tait, and without quoting, explains his views. He says professor Tait's researches have not been published *in extenso*, but a summary of results appeared in "Good Words" "some time ago."[13] These Mr. Lockyer presents in language from which the following are extracts: "In the case of comets of but small masses, the component materials would be small and far apart. * * * While the swarm which builds up the

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to explain the formation of worlds antagonistically to the Kantian conception, while that of the present writer was to gain a starting-point for the unfolding of that conception. Sir William Thomson is said to to entertain the opinion that the "origin of the planets was through a gradual accretion of meteoric matter."

[11] "World-Life," 1883, pp. 71-75, 482-3.

[12] It seems necessary, as will appear, to make special citations from the work mentioned. After speaking of the aggregation of nebulæ, the author continues: "In the nearer neighborhood of some great attractive centre, the velocity of one of these swarms is accelerated. Its form becomes more elongated. The internal movements of the parts become more vigorous, collisions are sharper, and flashes of light are evolved, and the posterior train is expanded. Further influence exerted by the central body increases all those consequences. The head of the swarm becomes permanently luminous. The long gathering swarm is now a comet" (p. 75). The contingencies happening to a cometary aggregation once introduced into our system, are next traced, "A cannon-ball moves 1400 to 2000 feet in a second, and yet its impact upon a solid body always develops a flash of light. But this velocity is mere rest when compared with that of a comet in its flight. Now in case of these mutual collisions among the parts of a comet, the velocities of some will be accelerated, and those of others retarded. Those retarded are liable, of course, to be accelerated again by other collisions, so that the total amount of motion in the assemblage should remain constant, so far as actions in the system are concerned. Nevertheless, the changed velocity of a part results in a change of intensity of action from without," etc. Thus, not to quote at length, the comet tary aggregation is partly pulverized, and gradually torn asunder—disintegrating into the meteoroidal stage (pp. 482-3). These principles are applied to the slow contraction of Saturn's rings, and to the zodiacal light.

[13] From Dr. Croll the writer learns that this was in the volume for 1875, p. 861. The date of publication does not appear.

comet is coursing round the sun as a whole, the individual members will themselves gravitate toward each other. * * * The stones colliding will generate heat, and some gas will be evolved; some members of the mass will be quickened, while other constituents of the mass will be retarded in their motion. * * * The result of these collisions would be such a smashing up of the constituents of the swarm that much finely attenuated material would be left behind, sufficient to reflect sunlight and to give rise to phenomena of the tail".[14]

Thus the suggestion came into existence that some of the nebulæ, as well as comets, are simply aggregations of stones, sand, fire mist and gases. This at least, was specifically enunciated by the present writer. Professor Lockyer inclined to adopt such a view of the constitution of nebulæ, as is shown in the ample and interesting series of papers referred to. In one of these he says: "The brighter lines in the spiral nebulæ, and in those in which a rotation has been set up, are in all probability, due to streams of meteorites with irregular motions out of the main streams, in which the collisions would be almost *nil*. It has already been suggested by professor G. Darwin [*Nature* volume XXXI, 1884-5, p.25]—using the gaseous hypothesis—that in such nebulæ "the great mass of the gas is non-luminous, the luminosity being an evidence of condensation along lines of low velocity, according to a well known hydrodynamical law. From this point of view, the visible nebula may be regarded as a luminous diagram of its own stream-lines."[15]

The question naturally arose whether a swarm of discrete meteoric bodies, in an aggregation of nebular dimensions, would manifest the behavior of a cooling and shrinking spheroid of gas. The essential conception of the nebular theory of the Solar system involves an elastic fluid and the conservation of an equilibrium figure, while the meteoroidal aggregation presents at first view, a discrete condition of solid constituents quite lacking the distinguishing properties of a fluid. As soon, however, as we conceive the constituents in a perpetual state of collision and rebound, the physical movements of fluid molecules are at once suggested, and we perceive that within certain limits of distance of the meteoric constituents, the meteoric aggrega-

[14] Nature, XXXIX, 402, Feb. 21, 1889.
[15] Nature, Nov. 17, 1887; *Roy Soc.*, Nov. 15, 1887.

tion is essentially a gross fluid, and might manifest the behavior of a fluid.

Professor G. H. Darwin undertook the analytical investigation of this question,[16] and in a memoir of extraordinary interest, established the following conclusions:—As far as frequency of collision is concerned, the hydrodynamical treatment of a swarm of meteorites is justifiable; the aggregation may be treated as possessing a coëfficient of viscosity such that if rotating, it would revolve nearly without relative motion of its parts, other than the motion of agitation; but in later stages the viscosity would be diminished to such extent that the central portion would probably rotate more rapidly than the outside—as some phenomena suggest to have been the case in our system. A further conclusion is, that the larger and less frequently colliding meteorites will gradually settle toward the centre, leaving the smallest and most frequently colliding meteorites—or fragments, particles or molecules—disposed at and near the surface, thus creating a maximum density about the centre, though its distribution is not according to the law of an elastic gas. It is further suggested that in the late stages of evolution, the meteors would be mostly absorbed by the central sun and planets, that their relative motion of agitation would be largely diminished, and that they would probably move in clouds—"the dust and refuse of the system"—with so infrequent inter-collisions that it might not be permissible to treat the cloud as possessing the mechanical properties of a gas.

A very different conception of the prenebular history of matter was suggested by Dr. James Croll, twenty-one years ago.[17] This supposes "that our sun was formed from a hot gaseous nebula produced by the colliding of two dark stellar masses, and that as the stars are suns like our own, they in all likelihood, had a similar origin." The considerations

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[16] His results are embodied in a memoir "On the mechanical Condition of a Swarm of Meteorites, and on Cosmogony," read Nov. 15, 1888, before the *Royal Society*, and published in the *Transactions*, vol. 180, A. pp. 1–69, with notes by the author to Dec. 19, 1888. The writer is indebted to professor Darwin for a copy.

[17] *Philosophical Magazine* May, 1868. The thought has been several times reproduced. "Climate and Time" chap. 21; *Quarterly Jour. Sci.* July, 1877; *Phil, Mag.*, July, 1878; "Climate and Cosmology," chaps. XVII, XVIII and XIX; "Stellar Evolution," 1889, 12mo, 218 pp. For the last two works named the writer acknowledges his obligations to their author.

which favor the theory are well set forth in Dr. Croll's recent work on "Stellar Evolution." The motion of the colliding masses is not supposed to be entirely due to the action of gravity—as according to the more recent conception of Sir William Thomson.[18] "If the masses were created, they may as likely have been created in motion as at rest; if they were eternal, they may as likely have been eternally in motion as eternally at rest. Eternal motion is just as warrantable an assumption as eternal matter." "A mass equal to that of the sun, moving with a velocity of 476 miles per second, would possess, in virtue of that motion, energy sufficient, if converted into heat, to maintain the present rate of the sun's radiation for 50,000,000 years."

"The collision of two bodies each half the mass of the sun would result immediately in a chaos of fragments. The enormous heat generated would further shatter and disperse the fragments. Much of the matter would be transformed suddenly into the gaseous condition. In the course of time, the whole would assume the gaseous condition, and we should then have a perfect nebula[19]—intensely hot, but not very luminous. As the temperature diminished, the nebulous mass would begin to condense, and ultimately, according to the well known nebular hypothesis, pass through all the different phases of rings, planets and satellites, into our Solar system as it now exists."

Here then, are two distinct conceptions of prenebular history:—First, The Meteoric Theory, as reasoned out, it is represented, by professor Tait, and independently by the present writer, and also, with convincing and admirable fullness, by professor Lockyer; Second, The Impact Theory, of which Dr. Croll's form postulates initial motion and Sir William Thomson's assumes initial rest. Under the first theory, the nebular mass undergoes a prolonged aggregation, heat resulting from the impact of descending contributions. Under the impact theory, dark bodies exist in immensity[20] whose move-

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[18] *Nature*, 27 Jan. 1887; *Proc. Roy. Institution*, vol. XII.

[19] Whether "a perfect nebula" is entirely gaseous is the question at present in doubt.

[20] Lambert conceived the existence of dark bodies as centres of the great cosmic systems. "Kosmologische Briefe ueber die Einrichtung des Weltbaus," Augsburg, 1761. Newcomb affirms that "not the slightest evidence favoring the existence of these opaque centres has ever been found."

ments, whether initial or gravitational, bring them occasionally into collision.

But there are prenebular inquiries prior to those reached by these theories. What was the antecedent history of matter which had attained the condition of meteoroidal masses? In the work already quoted, the present writer set forth the theory that the "universal world-stuff" postulated by Grove, Brodie, Hunt and many others, or generalized from the phenomena of meteors, is, in its state of ultimate attenuation, the ethereal medium conceived by Newton, Young, Saigey, Macvicar, Lodge and others.[21] He suggested, in other words, that out of this semi-spiritual substance may have germinated the molecules of common matter, and that the so-called ethereal medium may thus have been the ultimate condition of the matter of nebulæ.[22] Further considerations confirmatory of the doctrine of the continuity of planetary atmospheres with the interplanetary medium, were based, at a later date, on the fact that the gaseous atmospheric constituents fixed in coal-beds, carbonates and other forms, during the progress of rock-formation have been many times greater than could have been yielded by a terrestrial atmosphere of determinate volume and mass.[23]

The recent memoir of Dr. Huggins, "On the Spectrum, Visible and Photographic, of the Great Nebula in Orion"[24] is thought by some "to go a good way to overturn the views held by Mr. Lockyer, and recently advocated by professor Darwin, on the meteoric constitution of nebulæ." The present writer does not share in that impression. Dr. Huggins' researches confirm the presence of hydrogen, throw some doubt on the presence of nitrogen and perhaps still more doubt on Mr. Lockyer's contention for the presence of magnesium at a comparatively low temperature. Had he shown that the nebula is exclusively gaseous, the

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[21]Dr. Croll in allusion to this says: "Professor Winchell has advanced views similar to those of Tait and Lockyer regarding the nature and origin of nebulæ. But he, in addition, discusses the further question of the origin of these swarms."—"Stellar Evolution," p. 23.

[22] World-Life, p. 533, and more specifically, pt. I. ch. I §7.

[23]A. Winchell, "Secular increase of the Earth's Mass," *Science*, II. 820-1, Dec. 28, 1883. *Chemical News*, London, March, 1884.

[24]Read before the *Royal Society*, May 2, 1889, but not yet published—an uncorrected proof copy having been received from Dr. Croll by the present writer.

showing would have been adverse to the theory of a meteorics constitution of that part of the Orion nebula investigated. But the spectrum studied chiefly was a bright line spectrum, and of course revealed only gaseous conditions of matter. Such gases may have been merely an atmosphere bathing other portions of matter in liquid and solid states. This being so, the facts stated are quite compatible with either the meteoric or the impact theory of prenebular states. Moreover, Dr. Huggins himself supplies statements which indicate the existence of matter in other than the gaseous condition. He speaks of a "continuous spectrum," which, however, he attributes to the two of the four bright stars of the Trapezium which fell upon the slit. But he detects evidence that the stars *belong to the nebula*, in the fact that the bright nebular lines crossing the steller spectrum can be traced for some little distance into the nebula, showing that those stars are not merely optically connected with the nebula, but are physically bound up with it, and are very probably condensed out of the gaseous matter of the nebula. It may be mentioned that other nebulæ affording the bright lines of gaseity, exhibit stronger continuous spectra, while in the nebula of Andromeda, the continuous spectrum supersedes that of bright lines.

This is all intelligible without ignoring the probability of pre-gaseous conditions, and still more without denying non-gaseous matter of pre-gaseous origin, coëxistent with a conspicuous amount of gaseous matter. If the meteoric theory implies the aggregation of cold stones and sand, it implies equally the evolution of intense heat and resulting gases. So a nebula resulting from impact of single masses would consist similarly of solid and liquid fragments immersed in a gaseous atmosphere of high temperature. If under either theory, the temperature should reduce to a gaseous state, the entire matter of the nebula, that would furnish no reason for assuming that the nebula had been gaseous from the beginning of its existence.

To the writer, the present state of knowledge seems to justify the opinion that some nebulæ exist in a condition entirely gaseous, and others in a mixed state, while a few seem to have attained throughout, the condition of fire-mist—borne up probably, by a faintly luminous residual gas. It seems further, to justify the theory that all nebulæ have had a prenebular his-

tory—a growth or development from cold, non-luminous states of matter. The difficulty of admitting vast, dark cosmic bodies, whose existence is entirely conjectural, leads the writer to prefer the meteoric theory, which finds the requisite cold matter in all-pervading "cosmic dust," whose existence is actually revealed in the meteorites which course about the sun, and descend in "star-showers" to the planet on whose surface we dwell.

Ann Arbor June 15, 1889.

GLACIATION OF MOUNTAINS IN NEW ENGLAND AND NEW YORK.

BY WARREN UPHAM.

Read before the Appalachian Mountain Club, April 17, 1889.

II.

The most noteworthy observations on the glaciation of the White mountains are those of Dr. Edward Hitchcock in 1841, marking the upper limit of the usual drift deposits, striæ, and ice-worn ledges about 1,000 feet below the top of Mt. Washington; and of his son, professor Charles H. Hitchcock, who in 1875 found glacially transported bowlders on the very summit of this mountain.[1] The former wrote of Mt. Washington, and the other peaks of this range: "All the peaks which I ascended are made up of broken fragments of this slate, which have been entirely removed from their original position by frost, and form sometimes a coating of loose angular blocks several feet thick. This is particularly the case upon the summit of Mt. Washington, and downward about 1,000 feet; but in all the valleys between these peaks more or less of the rocks appear in place, and here I discovered many examples of embossed rocks. They are, as we might expect, much less distinct than in many other places less exposed to decomposing agencies, and I should probably have passed by them without recognition, had I not previously examined many other more distinct examples. So far as Mt. Clinton has been uncovered, it seems one huge boss more or less rounded. As we begin to ascend Mt. Pleasant, the embossed rocks are quite distinct; and here, too, are bowlders most evidently transported. Here, too, I discovered striæ running N. 30° W., S. 30° E., corresponding essentially with the general course of

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[1] Ibid.; APPALACHIA, vol. I.

striæ on the mountains of New Hampshire and Massachusetts. . . . Near the south foot of Mt. Franklin is another example of the embossed rocks with bowlders. . . . Finally, at the south foot of Mt. Washington, near a small pond called Lake of the Clouds, is a third example of the *roches moutonnées.* It is less distinct than at the other localities, as the rock here is more broken up by frosts; still it is impossible for a practised eye not to recognize them. And it ought to be stated that here it is the northwest exposure of the rocks that has been most powerfully acted upon, proving conclusively that the force was exerted from that direction."

Very rare bowlders and small fragments of gneiss foreign to Mt. Washington, which in its upper part is andalusite mica schist and gneiss, occur above the limit of the ordinary drift action, as similar foreign rock-fragments are found very scantily on the high portion of Katahdin to within 600 or 500 feet below its highest peak. But on Mt. Washington the drift fragments are scattered thus scantily quite to its summit, near which professor C. H. Hitchcock has obtained two bowlders, each weighing about ninety pounds. One of these is in the museum of Dartmouth college, and the other in that of the Boston Society of Natural History. The account of this discovery, which proves that the ice-sheet at one time overtopped even this highest peak of the northern Appalachians, is told by professor Hitchcock as follows:—

"The first suggestion of this novel proposition came to me the last day of July, 1875, from an examination of the somewhat rounded stones of small size lying along the carriage-road upon the northeast side of the mountain, about two hundred and fifty feet below the summit. I stumbled upon two bowlders of granitic gneiss foreign to the mountain,—one nearly ten, and the other six inches long. This raised the altitude at which transported materials existed to about 6,000 feet. Observation showed that these bowlders came invariably from the earth underlying the conspicuous angular débris common all over the peak above the line of trees. In repairing the road, the workmen usually dug beneath the surface blocks before obtaining a material suitable for their purposes, and there always seemed to be a plenty of it. . . . I examined the excavation made for the road between the house and stables, and obtained several small bowlders, four or five

inches long, corresponding in mineral structure with the ledges in Randolph and Jefferson, twelve or fifteen miles away. The general color of the rock is so like that of the mountain that one would not perceive the difference between them without close inspection. The mica is arranged differently in it; The white parts are more abundant, though in fine grains, and the rock is evidently the same with the upper member of what I call the 'Bethlehem gneiss' in the New Hampshire reports. The highest point at which stones of foreign origin were obtainable may be twenty or twenty-five feet below the very pinnacle of the mountain. Hence it is fair to conclude that every part has been covered by the glacial ice. . . . Just beyond the signal-station dwelling I found a flat ledge sloping a little northwesterly, but precipitous on the southeast. Atmospheric agencies have marred the surface so much that no striæ are visible, even if they ever existed. I had proposed to scrutinize every harder projection of quartz with a lens as this course sometimes reveals striation where other inspection is unavailing. Were this ledge situated near the Lake of the Clouds, where embossment is common, I should point it out unhesitatingly as an example of ice-sculpture, though much degraded by weathering. The shape agrees with that of thousands of glaciated ledges in other parts of the state. Other ledges on the mountain farther north resemble this one. Inasmuch as the transportation of materials is clearly proved by the presence of the Jefferson rock upon the summit a few rods away, it will not be unreasonable to believe that this apparent embossment is real. The altitude of the ledge is the same with that of the site of the travelled stones. The disposition of the large blocks upon the summit is noteworthy. Several acres of surface are covered by them far away from visible ledges. As you approach a ledge, it is easy to see what fragments have been separated by frost action, as the projections match the indentations. . . ."

Before this discovery, while it was believed that Mt. Washington and its neighbors rose above the ice-sheet at its time of greatest thickness, professor Dana had computed, from the slope of the ice-surface thus known, and from the courses of striation and transportation of bowlders in Canada, that the elevation of the surface of the ice-sheet over the northern border of New England was about 8,000 feet, and over the

Canadian watershed between the St. Lawrence and Hudson bay 13,000 feet, giving to the ice an average thickness of about 5,000 feet in the region of the White mountains, 6,500 feet on the international boundary, and not less than 12,000 feet on the Laurentian highlands.[2] It still appears to be true that the upper limit of the ice-sheet was about 1,000 feet below the summit of Mt. Washington during the greater part of the Ice Age, and that professor Dana's estimates of the thickness of the ice farther north are very probable. There seem to be good reasons for believing that the land at length sank beneath this heavy burden; and to that time I would refer the complete glacial envelopment of Mt. Washington, as well as the transportation of the highest, very scanty drift on Katahdin. This depression of the earth's crust led to changes of climate, from the rigorous conditions causing glaciation to mild temperatures by which the ice was finally melted; but at first the subsidence was perhaps attended by an increase in the thickness of the ice whose surface may have been maintained by the snow-fall during a short time geologically speaking, at its former altitude, while the area of the White mountains sank the 1,000 feet which would envelope the top of Mt. Washington in the ice-sheet. The mountain was not thus covered so long that the glacial current could sweep away much of the abundant frost-riven débris, nor conspicuously emboss any projecting knobs of rock, nor bring many bowlders and fragments of foreign drift. In the two hundred and twenty miles from the terminal moraine of Long Island, Martha's Vineyard, and Nantucket, north to Mt. Washington, the slope of the ice-surface therefore averaged in its maximum, about thirty feet per mile compared with the present sea-level and hight of the mountain, but was only about twenty-five feet per mile through the greater part of the glacial period. It is presumable, however, that in a process of subsidence of the land only the thickness of the ice-sheet, and not the slope of its surface, was increased when the mountain became wholly ice-covered.

The bowlders found on Mt. Washington were transported by a glacial current moving from northwest to southeast, and in the distance of probably fifteen miles from their parent ledges to the top of the mountain they were carried upward

[2] American Journal of Science, III, March, 1873, vol. v. pp. 198-211.

about 5,000 feet. Some of the courses of striæ reported by professor Hitchcock on other mountains in New Hampshire are as follows:—

Mt. Adams, west side, at hight of 5,500 feet	S. 58° E.
Near the gap between Adams and Jefferson	S. 33° E.
Lake of the Clouds intersecting	S. 22° E. and S. 52° E.
Between Mts. Franklin and Pleasant and the same between Mts. Pleasant and Clinton	S. 30° E.
Near the top of Mt. Clinton, north side	S. 47° to 52° E.
Mt. Clinton, south peak	S. 50° E.
Mt. Webster	S. 30° and 37° E.
Mt. Wiley, top	S. 42° E.
Mt. Field, top	S. 50° E.
Mt. Field, side towards Mt. Willard	S. 37° E.
Mt. Willard, top	S. 23° E.
Mt. Pequawket (Kearsarge North), two-thirds of the way from top to saddle between it and Bartlett mountain, at hight of 2,500 feet	S. 42° E.
Mt. Baldface, top	S. 23° to 28° E.
Chocorua, side	S. 42° E.
Mt. Whittier, West Ossipee, top	S. 47° E.
Red Hill, near summit	S. 62° E.
Mt. Prospect, Holderness, summit	S. 37° E.
Mt. Gunstock, Gilford, top	S. 62° E.
Teneriffe mountain, Milton, top	S. 42° E.
Pawtuckaway, north side	S. 72° E.
Dixville mountain, top	S. 54° E.
Mt. Agassiz, Bethlehem, top	S. 8° W.
Mt. Lafayette, above the Eagle Lakes, also	S. 8° W.
Moosilauke, top	S. 22° E.
Moosilauke, twenty rods east of summit	S. 27° to 32° E.
Gardner's mountain, top	S. 12° E.
Mt. Cuba, top	S. 28° E.
Kearsarge mountain, Warner, top	S. 46° to 51° E.
Ragged mountain, top	S. 23° E.
Monadnock, top	S. 21° E.

Deflected striæ are remarkably well shown on the sides of Monadnock, where the divided glacial current passed around and over it.

An inspection of this list, and of the far more numerous observations of striæ on the lower lands, published in the third volume of the "Geology of New Hampshire," shows that the prevailing direction of the ice movement was to the S. E. and S. S. E., bearing more toward the south in the southern and southwestern portions of the state and in the Connecticut valley.

Supplementing the observations of the Geological Survey of Vermont, Mr. Edward Hungerford published in 1868 a valuable paper on the glaciation of the Green mountains,[3] from which most of the following notes are derived, their order being from north to south. Striæ on the summit of Jay Peak, 4,018 feet above the sea, bear S. 40° E. Very large transported bowlders occur on the top of Mt. Mansfield, with striæ bearing S. 23° to 28° E. This mountain, the highest in the state, attains the elevation of 4,430 feet. Masses of quartz contained in the mica schist of the top of Camel's Hump, 4,088 feet in hight, show fine lines of striation, noted in three places, S. 10° W., the same with variation to due S., and S. 35° E. On the northeast side, about 700 feet below the summit, in the path to Ridley's station, striæ bear S. E. and S. S. E. It is also to be remarked that the rounded northwest side of Camel's Hump, and its precipitous cliff on the south and southeast, afford evidence of glacial erosion. Killington Peak, 4,221 feet high, has similar rounded outlines, forming a "well-defined northern stoss side;" and Mr. Hungerford observed numerous small bowlders of foreign rock within twenty feet of the highest point. He concludes that all these summits, the highest in Vermont, were enveloped by the ice-sheet.

The glacial current crossed the Green mountain range from northwest to southeast and south. It transported bowlders of the Burlington red sandstone across the range near Camel's Hump, where they were carried upward 3,000 feet above their source, and deposited them in the Quechee valley, near the Connecticut river, and in Hanover, N, H., about sixty miles from their starting-point.

Little is known of the glaciation of the Adirondacks; hence there is a rich harvest sometime to be reaped in that region. The group, consisting of Archæan granites, gneiss and schists, culminates in Mt. Marcy, or Tahawus (the "Cleaver of the Clouds"), 5,344 feet above the sea; and Mt. McIntyre, at 5,113 feet, is next in elevation. Mr. Verplank Colvin, in charge of the Adirondack survey, states that the summit of Marcy is contrasted with the other high peaks in its being destitute of glacial drift; but its embossed and rounded ledges, as he observes, indicate glacial erosion there, although

[3] American Journal of Science, II., vol. XLV.

its striæ have been obliterated by weathering.[4] Professor Fay also informs me that the top of this mountain and of several other prominent peaks visited by him in the Adirondacks are all similar in aspect to Monadnock, none belonging to the type of Katahdin and Washington. The contoured map of Mt. Marcy, drafted by Mr. Colvin shows that it is much steeper on the east and south than on the north and west, as would be its form under glaciation from the northwest, like the mountains of New Hampshire and Vermont.

This summit lies about one hundred and twenty-five miles west, and a few miles south, of Mt. Washington; and its distance north from the terminal moraine on Long and Staten islands is about two hundred and thirty-five miles. The average slope of the surface of the ice-sheet from its termination to the Adirondack mountains, was, therefore, not less than twenty-three feet per mile; and from the Catskills, where the upper limit of glaciation is known, it was not less than seventeen feet per mile. How much it may have exceeded these figures cannot be determined, but what we know of Katahdin and Washington shows that the peak of Marcy doubtless lacked only a little of rising above the ice-sheet at its time of maximum thickness. In this connection it is to be remarked that the change from a northward ascent of about thirty feet per mile south of the Catskills, to an average of seventeen feet per mile, or slightly more, for the next hundred and thirty miles to the Adirondacks agrees well with the slopes of the Greenland ice-sheet observed by Nordenskiöld, and with the northward ascent of the ice surface assumed by Dana in the computation above mentioned, namely, an average of ten feet per mile for the distance from the international boundary to the watershed north of the St. Lawrence.

Dr. R. P. Stevens states that along the valley of lake Champlain the general direction of the striæ is in parellelism with the valley from north to south, but with local deflections to the amount of 20°. On the higher hills and mountains near the west side of this lake, including some of the eastern Adirondacks, he finds the striation to be more commonly from northwest to southeast, which is also its direction in the

[4] Seventh Annual Report of the Topographical Survey of the Adirondack Region, to the year 1879.

Ottawa basin farther north. He also notes striæ bearing S. E. on Mt. Anthony in Saratoga county.[5]

In New Jersey professor John C. Smock's observations show that the ice-sheet covered the highest point of the state, which lies near its most northern angle, at an elevation of 1,804 feet. Its distance north from the terminal moraine is about thirty-one miles. The New York highlands and the Shunemunk and Shawangunk mountains are also glaciated to their crests. But in the Catskill mountains professor Smock finds that the glacial drift and striæ extend upward only to an elevation approximately 3,000 feet above the sea.[6] Their limit is thus a thousand feet below the highest summits, Slide mountain, the culminating point of this group, having, according to professor Guyot's determination, an altitude of 4,205 feet. The distance from Slide mountain south to the terminal moraine on Staten island at the sea level is a hundred and five miles. The ice sheet in this distance had an average slope of nearly thirty feet per mile, or slightly less than a third of a degree; and large areas of the Catskills rose above its surface at its time of maximum thickness and extent.

Professor Smock writes: "The amount of erosion in the Catskills has been very great, since the strata [sandstones and shales] are nearly everywhere horizontal, or inclined but a few degrees from the horizon. The main valleys appear to have been eroded prior to the glacial epoch, and the existing features were largely determined by the long-continued wear of preglacial waters; so that the ice-sheet did little beyond filling partly some of the valleys and abrading the more prominent of the lower ridges. The valleys are essentially of erosive origin, obscured, however, now by glacial débris in many places. In some of them, as that of the Batavia Kill in Windham, the Stony Clove and Woodland Valley, there are very plainly marked moraines, indicating the existence and retreat of local glaciers. The larger valleys of the Schoharie Kill, the east branch of the Delaware, and the Esopus creek, also have their moraines, though not so well defined. Subsequent to the retreat of the great mass of the continental glacier, these valleys were no doubt occupied by detached

[5] American Journal of Science, III, 1873, vol VI.
[6] Ibid., 1883, vol XXV.

glaciers. The torrents flowing from them evidently modified much of the older drift, and deposited it in a stratified form in these valley bottoms as we now see it. In this way the moraines were partly destroyed. Ascending these valleys to their head, the upper limits of the thick drift masses are reached, beyond which, on the steeper mountain slope, the explorer finds the evidences of glaciation in *roches moutonnées* and scattered bowlders only."

The general direction of the glacial current in the region of the Catskills, as shown by striæ, was southwestward, being directed normally toward the glacial boundary, which passes west-northwesterly from Staten island across northern New Jersey and northeastern Pennsylvania to Little Valley near Salamanca, New York.

With the slopes of the North American ice-sheet ascertained in Maine, New Hampshire, and New York, we may instructively compare that of the ice-sheet which moved westward from northern Scotland across the Minch and the Hebrides, found by professor James Geikie to have had a descent of twenty-five feet per mile; "but slight as that incline was," he remarks, "it was probably twice as great as the slope of the *mer de glace* that filled up the German ocean."

In Essex county, Massachusetts, forming the northeast corner of this state, the courses of glacial striæ and transportation of bowlders range from S. 30° E. to S. 50° E.; elsewhere in eastern Massachusetts they are generally about S. 20° E.; in the central portion of the state, about S. 10° E.; and on the mountains of Berkshire county, S. E. Dr. Edward Hitchcock reported striæ bearing nearly north to south on the top of Wachusett, and on Mts. Holyoke and Tom. In Rhode Island the striation is nearly due S.; and in Connecticut generally S. S. E. Professors J. D. Dana and C. H. Hitchcock have called attention to a deflection of the striæ along the Connecticut and Merrimack rivers to a course due south or a little west of south, conforming with the direction of these valleys.

Exceptions to the general course of striation, diverging from it 10° to 40°, are also occasionally found in all parts of New England and New York. Many of these deflected striæ doubtless belong to the time of recession of the ice-sheet, when the direction of flow close to the irregular indented

ice-border might deviate considerably from its former course. A large indentation of the ice-sheet seems then to have been formed within the Gulf of Maine, turning the latest glacial movements in the vicinity of Boston, as indicated by the trends of drumlins, toward the southeast and east-southeast. During the continued retreat of the ice this indentation probably extended across York county, in the southwest corner of Maine, coinciding approximately with the Saco and Ossipee rivers. Remarkably deflected striæ are found on each side of this tract, on the northeast being turned southwesterly toward it in Cape Elizabeth, Standish, and Brownfield, Maine, and on the top of Mt. Pleasant; while on the southwest they are turned easterly and even to the north of east toward it in the district east of Winnipiseogee and Squam lakes.[7]

After the departure of the general ice-sheet, local glaciers lingered, during probably only a short time, in deep valleys and ravines of the mountains. Indeed, at the present time the summer snow-arch in Tuckerman's ravine shows that a glacier would be formed there by slight changes in meteorologic conditions favoring glaciation. Notes of the striæ and morainic deposits of these alpine glaciers, and of the remnants of the ice-sheet itself, with local deflections of its currents during its dissolution within the mountain districts, are presented by professor C. H. Hitchcock in the reports on the geology of New Hampshire and Vermont, partly from his own observations and partly as observed and originally described by Agassiz, Vose, and Packard. The Androscoggin valley contained one of the most noteworthy local glaciers of the White mountains, by which a remarkable terminal moraine, described by professor George H. Stone, was formed across the valley on the boundary between New Hampshire and Maine.

Looking beyond the limited region that has been the theme of this essay, we may well glance again in closing, over the vast glaciated area of this continent. Nearly all the snow-fall forming the ice-sheet was brought by winds from the evaporated surface of the sea in temperate and tropical latitudes; and Dana and McGee were first to reach the conclusion, since established by observations about Hudson strait and bay and on the head-waters of the Yukon, that the moisture of the

[7] Geology of New Hampshire, vol. III. pp. 122, 194.

winds was almost wholly condensed and precipitated upon the southern part of the ice-sheet, so that it had a greater depth there than far north. The course of striæ and the directions in which the drift has been transported, together with the recorded observations of the upper limits of the drift on mountains, hills, and plateaus, indicate that a line of maximum accumulation of ice extended from Newfoundland west-northwest to the southern part of Hudson bay, and thence west-southwest to the east base of the Rocky mountains between the Old Man and Waterton rivers, about twenty miles north of the north line of Montana. From this line or belt of its greatest depth the surface of the ice descended both to the south and north and the currents of its motion in these directions produced the glacial striæ and drift.

In the culmination of each of the two principal glacial epochs, the thickness of the ice-sheet over central Newfoundland and Labrador was probably 3,000 to 6,000 feet, increasing to 10,000 or 12,000 feet on the Laurentian highlands and in the basin of James bay and over the south part of Hudson bay, the bottom of which is about 400 feet below sea level. Thence westward the ice-sheet in the earlier and more severe epoch of glaciation probably decreased in thickness to 8,000 or 7,000 feet in the region of Reindeer and Winnipeg lakes, and farther west it declined to a depth of only 2,000 to 1,500 feet at the Cypress and Sweet Grass hills. Contemporaneous with this northeastern ice-sheet in its time of maximum extent, vast glaciers issuing from the Rocky mountains pushed against its western border, and another ice-sheet was formed on the Pacific side of the continent, covering nearly all of British Columbia. The greatest thickness of this western ice-sheet was apparently between latitudes 55° and 60°, and at a distance of two hundred to four hundred miles from the coast, attaining probably a depth of a mile or more above the land surface. Thence its motion was southward to the northern borders of Idaho and Washington, westward through the mountain ranges of the coast to the ocean, and northwestward, according to Dr. George M. Dawson in the Lewes and Pelly valleys of the upper Yukon basin. In the earlier glacial epoch, and perhaps also the later, the northeastern and western ice-fields and the glaciers of the Rocky mountains became confluent, so that, when they covered their greatest area, one vast sheet of land

ice stretched across the continent from Newfoundland and cape Cod to Vancouver island.

During the second and last great epoch of glaciation, when the terminal moraines of the northern United States, Manitoba, and the Saskatchawan region were accumulated, the extent of the ice-sheet in Pennsylvania, New Jersey, and New England appears to have equalled or exceeded that of the earlier ice-sheet; but within the Mississippi basin it fell short of the earlier limit by a belt whose maximum width is about two hundred and seventy-five miles. The northwestward continuation of the outer terminal moraines of this epoch, beyond the north line of Dakota, is believed to coincide approximately with the continuation of the Coteau du Missouri and with the Neutral and Beaver hills, crossing the South and North Saskatchawan rivers respectively about three hundred and twenty-five miles and two hundred miles east of the Rocky mountains. The thickness of this later ice-sheet upon the area of Hudson bay and eastward was apparently as great as that of the earlier glaciation, but westward from Hudson bay it diminished in thickness more rapidly, probably having a depth of about 6,000 feet over Reindeer and Winnipeg lakes, and terminating east of the Hand, Cypress, and Sweet Grass hills, which had been islands surrounded by ice in the previous glacial epoch. As president Chamberlin has suggested, the great lakes of British America, namely, Winnipeg, Reindeer, Athabasca, Great Slave, and Great Bear lakes, with the Mackenzie river, may be found to sustain the same relationship to the western and northwestern boundary and terminal moraines of the later ice-sheet formed on the northeast part of our continent, that has been found along its southern border in the United States for the great Laurentian lakes and the Missouri and Ohio rivers.

THE MESOZOIC SERIES OF NEW MEXICO.

II.

By Jules Marcou.

Dr. Newberry was sent again to New Mexico in 1859, as geologist of Capt. Macomb's exploring expedition to the Grand and Green rivers of the great Colorado. A short résumé of this second expedition was published at once in the *Amer. Jr. Sci.* vol. XXVIII, p. 298, September, 1859, under the title: "Dr. Newberry's late explorations in New Mexico—he shows

Marcou's so-called Jurassic to be Cretaceous;" and seventeen years later his full "Geological Report," with eight plates of fossils, no geological map, 4to, Washington, 1876.

There are curious paragraphs in those two reports. In the résumé we read: "At Galisteo I found upper and lower Cretaceous rocks beautifully exposed, and in the lower Cretaceous sandstone (Jurassic of Marcou) dicotyledonous leaves" "The (true) Jurassic may be in New Mexico, but we have not yet detected it. Marcou's Jurassic is certainly not so." "Near Galisteo in the yellow sandstone specifically noticed by Mr. Marcou and regarded by him as Jurassic and identical with that of the Llano (Estacado), I found impressions of dicotyledonous leaves, which proves it to be Cretaceous." To sustain such sweeping assertions contrary to my careful observations about Galisteo, Dr. Newberry has not given a geological map of the vicinity of Galisteo nor even of any part of the Rio Grande del Norte valley, nor a single section; nor has he located with any degree of accuracy a single spot of the vicinity of Galisteo, and what is more he has never figured, described, or even named a single dicotyledonous leaf.

I found the Cretaceous rocks at Galisteo in 1853, and I gave a geological map, scale 1 : 900,000, with a tolerably exact distribution of the Cretaceous, Jurassic, Triassic, and Carboniferous systems, between Santa Fé, Pecos village and Galisteo. I published with good figures two Cretaceous fossils, found north and west of Galisteo: *Ptychodus whipplei*[1] and *Inoceramus lerouxi*. After finding for the first time in the United States the Jurassic system with characteristic Jurassic fossils: *Gryphæa dilatata var. tucumcarii and Ostrea marshii*, in

[1] Dr. Newberry in his description of *Ptychodus whipplei* (*Explor. Exped. from Santa Fé to junction of Grand and Green rivers*, p. 138,) says: The *Ostrea* of which Mr. Marcou speaks as occurring with *Pt. whipplei* is not O. *congesta*, as he supposes, but *O. lugubris* of Conrad. The place of *O. congesta* is a little higher in the series. *Gryphæa pitcheri* is found a few feet below." Every one of these statements is erroneous. It was Mr. Hall and not I, who described and figured the *Ostrea congesta* (*Pacific R. R. Explor.* vol. III. p. 100). I do not refer or speak of *O. congesta* in my *Geology of North America*, where are described my Cretaceous fossils. The *Ostrea congesta* described by Mr. Hall, was found by me at the same horizon and the same bed as *Pt. whipplei;* and the *G. pitcheri* found a few feet below, is a *Gryphæa* which has nothing to do with the *G. pitcheri* of the Neocomian of the Indian territory. A few pages before, p. 122, Meek in describing the Cretaceous fossils collected by Dr. Newberry, says that the Lower Division (=Dakota group) contains *Ammonites percarinatus*, *Exogyra*, *Gryphæa* (undetermined fragments), and leaves of *Salix*, *Platanus*, *Quercus*, in

the Tucumcari area. I followed the continuity of its strata with great care on account of a few denundations, to Los Estaros, Man of War butte, cañon Blanco, and the upper part of the mesa above Cuesta, San Miguel and opposite Pecos village. As to the Triassic system, I travelled over its strata, almost uninterruptedly, except a few spots of Neocomian and Jurassic, from the west side of the Delaware ridge to the old Pecos church; that is to say, a distance of 550 miles.

My observations can easily be controlled and followed, by means of my papers and my geological maps; while until now Dr. Newberry has failed to show dicotyledonous leaves in my Jurassic yellow sandstone four miles northeast of Galisteo, and at the top of the mesa above Pecos. Dr. Newberry has also failed to show in any way the existence of the *Gryphæa pitcheri*[2] of the Neocomian of Texas and Indian territory which he says he found "a few feet below the *Ptychodus whipplei*" near Galisteo and at Naciniento mountains associated with *Ostrea congesta* and *Inoceramus problematicus;* and finally he has completely failed to prove that he has "shown Marcou's so-called Jurassic to be Cretaceous." On the contrary Capt. C. E. Dutton in his "geological map of northwestern New Mexico (*Sixth Ann. Rep. U. S. Geol. Surv.*, plate XIV. p. 128, Washington, 1885)" has followed my geological map of 1853, mapping and coloring as Jurassic, all the road I followed and

a yellow or brown sandstone. "The vegetable remains * * * have been investigated by Dr. Newberry, in whose report the reader will find them fully described and illustrated." Nothing of the kind exists in the report. The white and yellow sandstone of the canon Blanco and of the Mesa-wall north of Galisteo, do not contain dicotyledonous leaves; and the existence of them in my Jurassic strata, as well as the existence of the typical *G. pitcheri* of the Indian territory Neocomian does not rest on any proved facts. All is imagination.

[2] To my knowledge the name *Gryphæa pitcheri* has been applied wrongly to five different species of *Gryphæa*, which have absolutely nothing in common with it. Like all the *Gryphææ*, the *G. pitcheri* varies in certain extreme limits, due to age, condition of preservation, and adherence of the lower valve, but retaining always the main characteristic of the species, which consists in having the beak of the lower valve—if not completely obliterated by adhesion—always *compressed laterally* more especially on the left side. Two of these false *G. pitcheri* exist in Texas, a third is the *G. dilatata* var. *tucumcarii*, a fourth is the *Gryphæa* related to *G. calceola* of Covero, and the fifth has been figured by Dr. C. A. White, in Wheeler's *Palæontology*, part I. vol. IV. plate XVII. p. 171. As to the *Gryphæa* so often quoted and referred to *G. pitcheri* by Dr. Newberry, it is impossible to know what it was, as I have said in my note "The original locality of the *Gryphæa pitcheri*" (*Amer. Geologist*, March, 1889, vol. II. p. 188).—A monograph of the American *Gryphæa* is in preparation.

marked as Jurassic from Covero to Zuni. And professor Robert T. Hill has recognized, in 1888, at the Little Tucumcari the Jurassic system, with its characteristic fossil the *Gryphæa dilatata* var. *Tucumcarii*, saying in a printed circular: "The reaffirmation of the age of the Tucumcari section along the northwest corner of Texas to be uppermost Jurassic, as originally described by Marcou."

The only change made by Dr. Newberry in his classification of 1858, is that he has become convinced that the fossil plants of the coal of Moqui, which he called a "Jurassic florula," do not belong to the Jurassic system, for he says: "It is, however, true at the present time (1876) that no Jurassic *plants* have been found on this continent;" showing once more how unreliable fossil plants are for the determination of the age of strata, and what degree of confidence may be placed in Dr. Newberry's palæobotanical conclusions.

The résumé of Dr. Newberry's exploration of 1859 contains a paragraph which I should not have written, notwithstanding the numerous provocations of my opponents; but as it applies so well to the extraordinary classification they have chosen to make and to perpetuate by all means, as well for the Mesozoic series of New Mexico, the Indian territory and Texas, as for the Palæozoic series of New York, Vermont and Canada, I shall quote it: "These unfortunate American geologists find to their confusion that the roof of their geological edifice was constructed before the foundation was laid" (*Amer. Jour. Sci.*, XXVIII. p. 299, Sept. 1859).

1863. MARCOU. In an exploration of eastern Nebraska and western Iowa made during the autumn of 1863, I recognized: first, the Dyassic system at Nebraska City, extending farther north my discovery of the Magnesian limestone or Permian of Arizona and of Topofki creek of 1853 ["Une reconnoissance géologique au Nebraska, Paris, 1864;" "Carbonformation und Dyas in Nebraska," von H. B. Geinitz, 4to, Dresden, 1866; and "LeDyas au Nebraska," Paris, 1867]; and secondly the true White chalk, with chalk like the European white chalk of England and France, at Sioux City. The main object of my visit in Nebraska was to see the original locality of Blackbird Hill, given as typical by Meek and Hayden of their Dakota group or lower Cretaceous No. 1. I found dicotyledonous leaves at Tekama, at Blackbird hill and at Sioux City;

and to my great delight I saw that the Dakota group was identical with my Nova-Mexican Galisteo division of the upper Cretaceous; several fossils being identical, such as *Ammonites percarinatus*, *Inoceramus problematicus*, *Ostrea congesta* and fragments of fossil fishes. But more, I saw at once that the so-called lower Cretaceous of Messrs. Hall and Meek, was not lower Cretaceous at all, but far above the true lower Cretaceous or Neocomian of Texas and the Indian territory, and even above the middle Cretaceous of Shawnee village (Indian territory); and I classified the Dakota group at its right place in the scale of American stratigraphy, as the inferior part of the upper Cretaceous or true Chalk division of Europe. At the same time I opposed the identification by Meek, Hayden and Hall of my Jurassic rocks of the Tucumcari area, with their Dakota group, insisting upon the absolute difference between the two systems ("Une reconnoissance géologique au Nebraska," Paris, 1864; "Les phyllites crétacées du Nebraska, par J. Capellini et O. Heer, Zurich, 1866; and "Le terrain crétacé des environs de Sioux City, de la mission des Omahas et de Tekama, sur les bords du Missouri," Paris, 1886).

The identification and synchronism of the Galisteo division of my survey of 1853, with the Dakota group of Sioux City, modified my classification of the upper Cretaceous of New Mexico, reversing two subdivisions; for it was evident that the gray marls with *Ptychodus*, *whipplei*, *Ammonites percarinatus*, *Inoceramus problematicus* and *Ostrea congesta* of the northern vicinity of Galisteo, were at the base instead of the top of the New Mexican White Chalk. I was glad of it, for in my rapid reconnoissance of 1853, I had regarded and noted the Cretaceous sandstone opposite Albuquerque as the youngest member of the Cretaceous system in New Mexico; but not having the time and occasion to follow the strata in order to see the contact of the three divisions established by me in the upper Cretaceous, I yielded with some reluctance to the palæontologic rule, insisted upon by my friend Louis Agassiz, that the genus of fish *Ptychodus* was characteristic of the utmost upper part of the White Chalk of England and France; and as a consequence I made a slight mistake in the stratigraphy of the upper Cretaceous of New Mexico.

IV.—Rectification to Table I, for the upper Cretaceous of New Mexico; made in 1863, by J. Marcou.

UPPER CRETACEOUS or White Chalk of New Mexico.	Albuquerque and Puerco area.	c. White sandstone, with *Ammonites novi mexicani*, *Baculites* and *Inoceramus*. It forms the whole mesa between Albuquerque and the Rio Puerco.—Lately, 1888, Mr. J. Collett, of Indianapolis, has discovered south of Albuquerque, at Carthage, near Socorro, in the continuation of the white sandstone an *Ammonites lenticularis* Meek, of the Fox Hill group of the upper Missouri basin.
	Galisteo area.	b. Black marl and sandy limestone with *Inoceramns lerouxi*. Ravine of the Rio Galisteo, at the crossing of the road from Santa Fé to Sanfelipe:—It represents the Colorado group. a. Gray sandy marls, with *Ptychodus whipplei*, *Ammonatis percarinatus*, *Inoceramus problematicus*, and *Ostrea congesta;* north of Galisteo, lying in discordance of stratification over or against the white and yellow Jurassic sandstone.—It represents the Dakota group of Iowa City and Nebraska.

1867. LECONTE. The entomologist, John L. LeConte, during a survey for the Union Pacific railway, touched my road by the 35th parallel, from the Rio Pecos above Cuesta, to Cañon Blanco, Tigeras, and Albuquerque. In his report: "Notes on the geology of the survey for the extension of the Union Pacific railway, E. D., from the Smoky Hill river, Kansas, to the Rio Grande," pp. 30-36, Philadelphia, 1868, he says, speaking of the rocks he saw in the Pass called Puertocito del Padre, in ascending the bluff from the Rio Pecos, to the mesa due east of Galisteo: "The section of a mesa of Cretaceous sandstone underlaid by the marl series of red, white and greenish strata of the Trias. Whether there be any Jurassic strata between the Trias and Cretaceous has not been ascertained" . . . . "it is very probable that the upper beds of the marl series may be eventually classed with the Jurassic." No fossils and no geological map, or exact section, are given.

1869. HAYDEN. Dr. Hayden in his "*Third Ann. Report*, pp. 165-166, Washington, 1873, says: "I am inclined to the belief that in the mesa, which looks so conspicuous on our left, on the road to Santa Fé (from old Pecos church), we have the first series of variegated beds, or Jurassic, including

the fine-grained sandstones that cap them, and the second series, Triassic; and that the remaining sedimentary beds are composed of Carboniferous, and possibly some Permian exists in that region." Exactly what any geologist passing over that road, with my geological map of New Mexico of 1853 in hand, would have said. No fossils quoted, no geological map, no detailed section; so Dr. Hayden's reconnoissance of 1869, from Pecos to Santa Fé, was simply a summary repetition of my observations.

1879. STEVENSON. Now we come to the survey executed "somewhat closely, from Las Vegas to Galisteo creek in 1879," by professor J. J. Stevenson. It is published in a 4to volume, called vol. III, *Supplement, Geology;* Wheeler's *U. S. Geogr. surveys west of the 100th meridian*, Washington, 1881.

The volume contains fossils, sections and a geological map of a "Part of north central New Mexico," touching and embracing in its limit some part of my geological map of New Mexico of 1853, so that comparison may be made. Scale of the map 1 : 253, 440. We must say at first that no Mesozoic fossils are figured or described, and that no list of species is to be found in any part of the volume, which relate to the Mesozoic rocks. "The title used by professor Stevenson in his paper in THE AMERICAN GEOLOGIST, vol. III. p. 391: "The Mesozoic rocks, etc.," seems to imply that his classification and description are entirely based on palæontology; but on the contrary, all his remarks, descriptions and classifications, as well in his paper as in his large 4to volume, are purely lithologic; the palæontology is never mentioned anywhere, and even the stratigraphy is seldom referred to, more especially the discordance of the strata, which is passed entirely unnoticed.

The classification on the map is:

$$\text{Cretaceous.} \left\{ \begin{array}{l} \text{Laramie.} \\ \text{Colorado.} \\ \text{Dakota.} \end{array} \right.$$

Linear outcrop of Jura-Trias.
Carboniferous.

Besides these are special divisions for the Tertiary, Quaternary, Igneous and Crystalline rocks.

Let us compare the only two geological maps of central New Mexico, of a tolerably large scale, in existence until

now. On professor Stevenson's map, the Dakota group—the only Cretaceous group I shall refer to—occupies all the mesa, from its extreme limit or rim, from near Lamy Junction to opposite San Miguel, extending west almost to the village of Galisteo. On my map the Dakota Cretaceous is limited to only three miles north, east and south of Galisteo; and all the vast mesa from its rim to only three miles from Galisteo is occupied by the Jurassic rocks, with three outcrops of Trias inclosed, no one of which is marked on Stevenson's map.

Professor Stevenson has limited what he calls a "linear outcrop of Jura Trias," 700 feet thick, to the perpendicular cliff, which begins at the rim of the mesa, and follows all the anfractuosities of the mesa wall. It is limited to a sort of stone wall, of a serpentine-like form, unknown until now in the world, for two great systems of strata, the Jurassic and the Triassic, combined in one, almost horizontal or very slightly inclined. On my map the Trias, 1,500 to 2,000 feet thick, occupies not only the mesa-wall, but extends all over the valley of the Santa Fé stage road, and also down the whole valley of the Rio Pecos as far as south of Antochico, an area which has been colored by professor Stevenson as belonging to the Carboniferous.

As to the Jurassic system at Cañon Blanco, at Cuesta, and opposite old Pecos church, the thickness is about 250 feet and very likely more, in its extension over the mesa. And both together, Jura and Trias, instead of being a serpentinuous linear outcrop as marked on professor Stevenson's map, on the contrary occupy a vast surface, as I have colored them on my map; and they are not confounded in a single system anywhere.

On my map the Carboniferous is limited to the north of the Santa Fé stage road, and I have placed the Trias in direct contact with the Azoic or crystalline rocks, just north of Lamy Junction, where the stage road crosses the crystalline rocks area. On professor Stevenson's map there is no contact of the Trias with the crystalline rocks, and we see instead a large band of Carboniferous surrounding the crystalline rocks, which certainly does not exist at the stage road crossing. West of Pecos village I have delineated on my map the Carboniferous approximatively, because I was not there, and what I know of it was obtained in looking over from the top

of the mesa opposite old Pecos church. Professor Stevenson has extended there the Carboniferous, on the whole area of the Rio Pecos valley, in places which to my knowledge are occupied only by the Triassic system.

Professor Stevenson divides his Dakota group into upper, middle and lower, with a thickness of no less than 1,700 feet, admitting an abnormal increase of thickness, and a lithology very variable and differing from the Dakota of the state of Colorado. He does not give the name of a single fossil, and passes silently over the finding there by Dr. Newberry of dicotyledonous leaves and of *Gryphæa pitcheri.* He calls it a "Dakota group greatly expanded," "but while so doing made the remark that the whole series *may be* Triassic, or *may be* Cretaceous, the grouping having been made simply for convenience;" an uncommon way of classifying Mesozoic rocks. And professor Stevenson adds: "This remark is too narrow, as it left the Jurassic out of consideration . . . there is a possibility that some portion of this *may belong* to the Jurassic. But the writer is inclined rather to look upon it *all as belonging to the Cretaceous.*" (THE AMERICAN GEOLOGIST, vol. III. p. 396, Minneapolis, June, 1889.)

These quotations and remarks show what sort of confidence can be given to professor Stevenson's geological map of New Mexico, and to his classification and description of the New Mexican Mesozoic rocks.

CLASSIFICATION OF NEW MEXICAN AND TEXAN MESOZOIC SERIES. As a résumé the following Table V, (p. 225) expresses the views entertained from the beginning of the classification of the various formations, by their different authors. They are placed in order of dates.

I shall add that Dr. Newberry said at the Berlin meeting of the International Congress of Geologists: "Je suis fondé à dire que quant au Permien proprement-dit, il n'exist par dans les Etats Unis." Mr. James Hall joins Dr. Newberry in his view of suppressing the Dyassic system in America (*Congrès Géologique*, 3me session, 1885, p. c. Berlin, 1888). Professor Stevenson in his report of the sub-committee on the Carbonic (THE AMERICAN GEOLOGIST, vol. II. p. 248, Minneapolis, 1888) has suppressed the Dyassic system in North America; according to his views and observations the Dyassic fauna

and flora belong simply to the upper Coal Measures, and even only as a sub-division or sub-étage of the 4th order!

V.—Table showing the classification of the Mesozoic series of New Mexico, the Panhandle of Texas, and the Indian territory.

<table>
<tr><th colspan="2">J. Marcou, 1853.</th><th>James Hall. 1857.</th><th>J. S. Newberry. 1857-76.</th><th>J. J. Stevenson. 1879-89.</th></tr>
<tr><td rowspan="3">Cretaceous System.</td><td>Upper Cretaceous or White Chalk (N. Mexico.)</td><td>Upper and Middle Cretaceous; II., III., IV., V.</td><td>Upper Cretaceous.</td><td>Laramie group. Colorado group.</td></tr>
<tr><td>Middle Cretaceous (Indian Ter.)</td><td rowspan="5">Lower Cretaceous No. 1, or Dakota group.</td><td rowspan="3">Dakota group.</td><td rowspan="3">Dakota group.</td></tr>
<tr><td>Lower Cretaceous (Neocomian) (Indian Ter.)</td></tr>
<tr><td colspan="2">Jurassic System. (Tucumcari.)</td></tr>
<tr><td colspan="2">Triassic System. (Along the Canadian river.)</td><td>Triassic. (in part.)</td><td>Linear Outcrop of Jura-Trias.</td></tr>
<tr><td colspan="2">Dyassic System. (Topoki creek and Colorado Chiquito.)</td><td>Permian or Trias.</td><td rowspan="2">Carboniferous.</td></tr>
<tr><td colspan="2">Carboniferous.</td><td>Carboniferous.</td><td>Carboniferous.</td></tr>
</table>

Conclusions. When I entered on the very broad area of Mesozoic strata, on the 35th parallel, I was happily prepared by a rare training, for the work before me.[1] During 1846, '47 and '48 I had published the most detailed and rational classification of the upper Trias, of the whole Jurassic system, and

[1] The undertaking of a crossing from the Mississippi to the Pacific shores was considered then, 1853, so hazardous, that all the geologists of any standing, to which the offer to accompany the three expeditions sent by the government for the Pacific railroad explorations was made, declined to go. Strongly pressed by professor Henry of the Smithsonian, who made me the offer, entirely unsolicited by me, and who proposed to me to choose the road and expedition which pleased me most, by a happy chance, I took the most southern road, where the Mesozoic series is found covering two-thirds of the distance, and where it is more developed than on any other line across the continent.

of the Neocomian of the Jura mountains of France. Besides I had had the precious advantage of having carefully explored the whole series of the Trias, Jura and Cretaceous systems in central France, in Switzerland and southern Germany. My classification and nomenclature for the "Jura salinois" had been accepted and used by Bernardh Studer in his "Geologie der Schweiz," by Albert Oppel in his "Die Jura formation, Englands, Frankreichs, und südwestlichen Deutschlands," by Alcide d'Orbigny in his "Cour de paléontologie et de géologie stratigraphiques," by F. Jules Pictet, in his "Traité de Paléontologie," and by all observers and writers on the Mesozoic series of central Europe; and they are still used even to this day as typical for the Jura area.

Notwithstanding such an excellent preparation, and the care I took to submit my fossils to Louis Agassiz, d'Orbigny, d'Archiac, Deshayes, Pictet, etc., my observations and classifications along the 35th parallel were not only opposed, but rejected in a lump by an association of geologists led by Messrs. James Hall and J. D. Dana. The character of the opposition may be sufficiently indicated by the quotation of a single paragraph of Mr. Dana, who says: "In conclusion, we would say that our reconsideration of the labors of Mr. Marcou in America has not raised our estimate of their value. We know well that if any American geologist had mapped our strata and synchronized those of America and Europe on such data as have satisfied the author of the 'Geology of North America' he would have been deemed young in the science, with much yet to learn before he would have a sober hearing." (*Amer. Jr. Sci.*, vol. XXVI. p. 323, Nov., 1858.)

The most singular part of that opposition is that it is made by persons, no one of whom has ever studied with anything like thoroughness, practically and theoretically, a single bed of the Mesozoic rocks of Europe; and no one of whom then, in 1857, had seen anywhere west of the Mississippi river the American Mesozoic rocks. When read calmly by unprejudiced geologists and by observers who know practically any of the typical regions of the Trias of Würtenberg, of the Jurassic of the Jura mountains, of Burgundy, Normandy and England; of the Neocomian of Neuchatel; of the Gault and White Chalk of the Paris basin; and who have made practical researches in the field in Texas, Kansas, the Indian territory, New Mexico

and Arizona, the critics and strictures of my adversaries can not be taken seriously into consideration, having no basis to rest upon, either palæontologically, lithologically or stratigraphically.

Instead of improving my classification of the American Mesozoic series of 1853 and contributing to the progress of American geology all the efforts of my critics during the last thirty-six years have been directed to prevent its acceptance. They have failed to give a single new fact, only mixing the series of Mesozoic strata in a hopeless mass of confusion and errors; and by their obstruction preventing the acceptance of truth and misleading the geologists who have trusted them.

I am glad to say that a new generation of young observers has at last come to the front; and that already the Necomian has been signalized on vast surfaces of Texas and in southern Kansas; the Jurassic is recognized in the Tucumcari area and western New Mexico; the Trias is extended south and north of my line of travels by the 35th parallel; and finally the Dyas (Permian) of Topofki creek has been explored again and recognized as such, and its extension north into Kansas is also admitted.

Post-scriptum.—Two errors in the printing of the first part of my paper require explanation.

1. At p. 162 the designations given at the left hand of the section of Pyramid Mount by Mr. James Hall ought to show that the bracket under the words: "corresponding to Nebraska section No. 1," does not stop at division A of the upper Keuper, but goes indefinitely lower down, as it is printed in the *Mexican boundary line*, vol. I, p. 135; for Mr. Hall incloses in his Nebraska section No. 1, not only two-thirds of my Jurassic system, but also the whole Trias and the whole Dyas.

2. At p. 159 the editor says in a foot note, in regard to my specimens placed without my consent or even knowledge in the hands of Mr. James Hall: "They were placed in his hands by order of the chief of engineers, through Mr. W. P. Blake." The chief of engineers had absolutely nothing to do with the whole matter. Here are the facts.

Obliged by bad health to go to Europe, by doctor's order, I begged leave of absence from Capt. A. W. Whipple, chief of the explorations by the 35th parallel, my direct and only chief, who acceded at once. Almost at the last minute, when I was on the point of putting my foot on the deck of a Cunard steamer, I was ordered by Jefferson Davis to remain in the United States, or to give up my notes. It was materially impossible to obey either alternative. After my arrival in the Jura mountains, I surrendered my note-books and specimens to the secre-

tary of the American minister in France, who gave me a discharge and receipt.

According to a special act of Congress, dated March 31, 1853, the explorations for the most practicable route for a railroad from the Mississippi river to the Pacific ocean, were placed directly under the charge of the secretary of war, then Jefferson Davis, who at once established a special office entirely independent of the chief of the topographical engineers, or of the chief of engineers. The head of that special bureau reported directly to Jefferson Davis. In August 1854, the chief of the new office was Capt. A. A. Humphreys, topographical engineers. I must say that my friends Capt. A. W. Whipple, J. Pope and A. A. Humphreys did all they could in their subordinate positions to have Jefferson Davis rescind his order and allow me to write my report. Even more, professor Joseph Henry of the Smithsonion institution, made several direct and personal applications to Jefferson Davis without any success. Capt. Humphreys finally delivered my note-books and specimens to Mr. W. P. Blake, and not to Mr. James Hall, to describe and prepare a report.

In entering on his duty Mr. Blake wrote me saying: "If you wish to present any modification or explanation of your views, please write me and I will regard your wishes—being desirous to accord you every privilege." Mr. Blake not only placed my specimens and note-books in the hands of Mr. James Hall against my wishes, but not satisfied with his extraordinary report of my route, read before the American Association for the Advancement of Science, at Albany, August, 1856, a violent and wholly incorrect paper against all my work and researches in American geology.

A few extracts from letters of my beloved and much lamented chief A. W. Whipple, since killed at the battle of Chancellorsville, May, 1863, a major general, when fighting against the troops of Jefferson Davis, will show his views on the subject.

In a letter to my correspondent in Boston, Mr. A. E. Belknap, dated April 13, 1855, he says: "I feel assured that Mr. Marcou has behaved in the most disinterested as well as honorable manner." It was in regard to the giving up of my note-books and specimens, and finishing my account with the two surveys of Whipple and Pope.

In a letter dated Oct. 23, 1855, Washington, Whipple says: "I received from baron de Humboldt a letter speaking very highly of you, and endorsing your discovery of the Jurassic formation upon our route. I think there will be an effort to criticise that part of your report, but doubtless the effect will be to give you more credit in the end."

Finally in sending me his final report he says: "I hope in perusing vols. 2, 3 and 4 of the Pacific Rail Road reports, you will perceive that I have endeavored to prevent injustice from being done to you. It is my opinion that your enemies have, by their course, injured themselves in the estimation of the scientific world."

As to general Humphreys, late chief of engineers, I have received from him all sorts of proof of his friendship, asking me to renew my connection with the engineer corps, which I did, in accepting first, an exploration of a part of southern California in 1875; and second in helping Capt. A. W. Wheeler in his report on the "Third International Geographical Congress, at Venice, Italia," 4to, Washington, 1886, which contains such a complete report upon the national geological surveys of the world, due entirely to me, although my name does not appear in the title, but only and sparingly in the introductory note.

CAMBRIDGE, MASS., September, 1889.

NOTE-TAKING AND THE USE OF MAPS IN GEOLOGICAL FIELD WORK.

By AUG. F. FOERSTE.

For geological work covering only a small area and confined to the consideration of simple, or at least single problems it is often unnecessary to keep any detailed system of notes. As the area under investigation increases in size, or the problems suggested by the same become more intricate it is no longer safe to trust to memory for the facts, and notes carefully prepared in the field are imparatively demanded. If the notes taken for this purpose are not too numerous great individuality of methods of recording the same may be permitted without detriment to the work or loss of time. With each man, however, there is a limit at which notes arranged indiscriminately can no longer be readily found, and some sytem must be devised by which notes referring to any part of the country under investigation may be readily found or the localities described in any series of notes may be readily traced on the map. Having frequently noticed the difficulties experienced by geological friends in the use of methods of many different kinds, I have thought that possibly it might be of some assistance to geologists in general to describe a system I devised some years ago, which as a matter of originality is not of a high order, but which for its practicability in actual field work has shown fewer defects than any system I have actually used, in all cases where the country under investigation has been accurately mapped.

A map or series of maps covering the entire country under investigation is secured. On these are traced two series of parallel lines at right angles to each other. It has been found in practice that a distance on the map corresponding to one

minute of longitude or latitude is the most convenient interval between these lines. The parallels or meridians already marked on the map will be of assistance in determining the positions for the smaller divisions here desired. Each square or parallelogram thus formed is considered as an individual in the use of the map and the localities investigated in each are numbered consecutively in the order in which the notes have been taken in the field. In practice we have never found more than forty notes necessary in any one square or parallelogram (we shall call these divisions squares hereafter, although mathematically this nomenclature must be considered incorrect for most parts of the world). The notes are numbered in such a way as to correspond with the figures in the map. This method has the advantage in not requiring the use of large numbers running into the thousands, and therefore permits the designation of a greater number of localities in close proximity to each other if found necessary or convenient by frequent exposures in the field. It becomes necessary, however, to designate by some means or other the squares, since in this method the same numbers are apt to occur in any or all of the squares. For this purpose some parallel and some meridian dividing the field somewhere near the center is taken and all the squares running northwards of the parallel are marked consecutively with the ordinary printed capital letters used by the English. Omitting the letters already employed the squares south of this parallel are marked in the same manner by letters of the Greek and Russian languages. East of the meridian accepted for reference the squares are marked by the small written letters of the English script, and west of this meridian by the small written letters of the Arabic language. This does not necessitate the understanding of a single one of the characters in use. They are merely conventional figures used to designate squares and their convenience lies in the fact that they are simple, readily made, easily recognized, and being the result of centuries of human activity in the art of using written and printed characters, are apt to be superior in convenience to any conventional figures invented by ourselves.

To designate any locality in the notes it is only necessary to mention before each note the printed capital and the small written letter designating the square together with the number

of the locality. On the map itself the number alone will be sufficient, the squares being supposed to be permanently labeled before entering the field. As a matter of experience it has been rarely found possible to secure a map which would stand the test of continued use in the field without the abras-use of the map and the erasure of the notes. It has been found convenient, therefore to cut up each map into pieces of such size as are likely to correspond to the capacity of each note book in use. For note books 13 by 20 cm., containing a hundred pages, sections of the map corresponding to fifteen degrees of longitude and the same of latitude have been found most convenient. Each note book containing such a section may be conveniently labelled across the edges of the leaves by the name of the largest town in that section of the map or some other prominent characteristic. That section of the map which is intended to accompany any particular note book is then cut up and pasted permanently on the cover and leaves of the first part of the book. If the note book is made as it should be of good stout linen paper a thin map in this condition will last as long as the book will hold together; whereas the continued folding and unfolding of a single week's energetic work in the field would seriously injure the same. For pasting in the book some form of fish glue, as Page's liquid glue should be employed.

As to the method in which the sections of the map shall be cut up considerable individuality may be allowed, the object being to have the pieces of such a size that when pasted in the leaflets of the note book a margin will be left on all sides to further protect the map and also to permit the labelling of the squares by tiers along the sides of each piece so as to leave the map itself as free as possible for the insertion of the number of the localities. For a map printed on the scale of a mile to 26 mm. and a note book 13 by 20 cm., my own habit is to cut the upper part of the map into six pieces, 5 minutes broad and 6 minutes long. There are formed in this way three pairs, the upper pieces of each being pasted at the head of the book and the lower one at its base on the opposite leaf. This will fill six pages. The remainder of the map is cut into two pieces and pasted into the book at right angles to the remainder, filling two pages more.

It would be equally convenient, perhaps, to cut the map into

nine equal pieces and paste them in according to some self-arranged plan. When the map is on the scale of one mile in 32 mm. the map could be divided into pieces 3 minutes long and 2 minutes broad, again leaving an irregular strip to be stowed away in some fashion. For persons to whom such irregular cuttings are inconvenient the original sections could be made 12 minutes long and broad, which would cut up into equal pieces for both scales of the map. Where exposures are not densely crowded and the problems under investigation are not exceedingly intricate, maps on the smaller scale have been found sufficiently large and more convenient since more of the map is brought on each leaf. Where intricate problems are being studied a map of the larger size is often of convenience, and any failures on the part of this to serve the purposes of the field-work can be remedied by pasting in, where required, some map on a still larger scale which then may be referred to its appropriate square on the larger map, but is itself designated by some of the smaller letters of the Greek alphabet, and all the notes are referred for the time being to this smaller map instead of the one ordinarily in use; and the fact that such a subsidiary map is being used can be then indicated on the general map of the same note book by inserting the Greek letter designating the same in the place covered by the subsidiary map. It may often be considered desirable to construct such subsidiary maps at once in the field, when they may be labelled in the same way as though pasted in from some printed source.

A section or small sketch map practically explaining only the condition of affairs at any one locality may be entered under the appropriate figure designating that locality without further reference.

The advantage of this system becomes very great when taken in connection with the collecting of specimens in the field, since the mere designation of the locality by means of two letters and a single number is sufficient for any locality where only one kind of rock is found. Where several kinds of rock occur at the same locality a small printed letter of the English type is hastily inserted in brackets in that part of the note describing the place and the particular kind of rock collected. Each new letter added in the note signifies a new kind of rock or at least a specimen gathered at the same locality but at

some distance from rocks designated by another letter. It has been found convenient to designate any connected series of specimens from the same locality by the same letter, as for instance in case of a series of specimens showing the effects of contact metamorphism induced by some dyke upon the country rock. The individual specimens collected are then designated by the distance at which they are from the contact line. Any further record desired had best be written out upon the label. But where many sections are examined and several series along the same dyke are collected I have found it convenient to place on the label after the number designating the distance from the contact line the direction in which the section from which the series of specimens were collected, ran and placing a line above the number expressing distance, if they were collected before such contact line was reached passing in that direction and a line below that number if collected after the contact line had been passed. Thus, B. f. π 4, would indicate that the locality indicated by a certain note or label, was number 4 on a certain subsidiary map marked π in the note book and which was used to supplement that portion of the map covered by the letter π on the square B. f. on the original sheet. A. b. 36, d. $\underline{14}''$ (N38W), would indicate that the locality thus indicated was at the place marked 36 on the square A. b. of the original map. For further designation it is necessary to refer to the note book where under the note marked A. b. 36, and in the text of the same a letter d. is found in brackets at the beginning of a description in the field of a contact perhaps between a granite intrusion and a sedimentary sandstone. The figure 14'' after this letter on the label accompanying the specimen collected shows that it was found fourteen inches from the contact, the direction of the section is indicated later to have been made in a N. 38 W. direction and the line under 14'' indicates that the specimen was collected after ~~before~~ said contact line was reached, namely on the N.W. ~~S. E.~~ side of the contact line.

When fossils are collected in new places where the horizons have not been carefully established collectors should not fail to designate the exact hight in the series at which any specimen may have been secured, if time for such accurate labeling can be found. Although the mingling of fossils from different horizons at some one locality while distinct elsewhere, is not

by any means a new phenomenon, yet it is possible that some localities thus published owe their interpretation to indiscriminate collecting, a fact further aggravated by the common practice that the persons who describe the fossils have scarcely time to collect them. For this purpose each locality is usually divided into various horizons by lithological characters if the same be present and letters are used designating the lines of separation, followed by a number indicating the number of feet above the same at which a certain specimen was found. English capitals are usually used to designate these lines. Thus, D, r, 7, G, 38′, means that a specimen was found at a locality marked 7 on the square of the original map marked D, r. A reference to the notes will show that G indicates the horizon at the top of the third series of sandstones perhaps at some quarry or other, while the appended figure indicates that the fossil was collected thirty-eight feet above the same. A minus sign (—) before the number would indicate that it was collected thirty-eight feet before that horizon.

In glaciated countries where the strata are lithologically quite distinct, and are tilted at angles of 45 degrees or more, or where there have been eruptions of volcanic material, or where a fault has brought dissimilar rocks together the structure may have been considerably obscured by the drift. In such places the drift itself will very frequently furnish clews as to the character of at least the general distribution of the larger masses of rocks of similar lithological features thus hidden. As a rule, admitting many exceptions, and which must be studied by practice, it may be stated that along an east and west contact line the rock on the south side will be apt to appear in the surface drift, or in the fence walls, if the surface drift has been disposed of in this way, in angular fragments, within at least a few hundred feet from the contact line, while the angular bowlders derived from rocks found in situ on the northern side of this contact line, appear in very much diminished quantity, half a mile south of the contact line, and are reduced to about 30 per cent of the angular drift three-quarters of a mile south of said contact line, the bowlders being often more or less rounded. One mile south of the contact line only occasional bowlders are found, often quite rounded or diminished in size. Noting the percentage of the bowlders of various kinds in the fields and fence walls

of a geologically varied country becomes often, therefore, a means of determining their superficial area in situ, and determining their contact lines with others and especially when igneous rocks are present in districts otherwise unmanageable; while the actually formed exposures serve as a check on this kind of work. N. and S. contact lines are not so readily determined in flat countries at least, the bowlders often deviating as much as thirty degrees from the course supposed to have been taken by the moving agency; still at times even this variation is not too great to admit of at least some results. In indicating the localities at which such observations are made on the map a dot is placed immediately after the number or some other sign is used to distinguish the same from localities where actual exposures have been found.

The most convenient note book for general use is one in which all the leaves are cross-ruled by parallel lines 5 mm. apart dividing the pages into numerous squares. They should be stitched together along the end, and not on the side, and the writing should pass horizontally across the page, along its shortest diameter. The first three series of squares along the whole length of the book should be left free of all kinds of writing, being used solely for the indication of the locality, including the two letters designating the square and the number designating the locality. In this way the pages may be readily scanned for some note desired, the letters indicating the locality, standing out clearly. Each page of the book should be numbered. At the end of the book the last three pages could be utilized by placing in an index of the notes. This is best done at the close of a season's work when the notes are being worked up, since the number of notes entered in different squares will be very unequal. The best series of indexing requires only two longitudinal series or columns of squares in the note book for each set of localities from the same square and consists in placing in the two squares at the head of two columns the letters indicating the particular square indexed in red ink. Then in black ink the localities of each square on the map are marked in the first column in the note book and the corresponding page on which the note itself is found is placed in the second column. One page will serve for several columns of this kind and three pages are usually sufficient for indexing one hundred pages of notes. Since this

is clerical work of the simplest order, some school boy or girl may be readily entrusted with this indexing at a very reasonable expense.

For use in the field a 6 H. Faber lead pencil has been found the best, both for marking the map and for writing the notes. It will not suffer from rain as would any ink. It will not rub nor need as frequent resharpening as would a softer lead pencil, and if good white linen paper note book be used, it is readily legible. Linen paper has the additional advantage of being very strong, holding the maps pasted in the same firmly, and does not suffer as readily from the rain. The note book itself should be covered by undyed leather even if its general appearance be less prepossessing, since rains will come unexpectedly and dyes will penetrate the leaves.

The best compass is one in which the degrees are marked 0 at the N. and S. poles and then are numbered both toward the E. and W., forming four quadrants numbered from 0 to 90. All strikes should be referred to the N. pole, for instance, either N. 30 W. or N. 30 E., never S. 30 E. or S. 30 W. This obviates many slips made in counting up the number of degrees variation on a compass numbered up to 360 degrees, making a desperate effort to remember a few moments later whether at that particular moment you were standing with your face towards the N. or towards the S. The bar holding the needle when not in use should be controlled by a spring managed by pressure on the outside, and not by a screw, as in the larger instruments in use, since the screw arrangement sometimes leaves the bar neatly poised in some position holding the needle, from which very rough shaking, spoiling the delicate mounting of a good needle, will alone bring it down.

Maps too large or too small may easily be redrawn by use of the pentagraph, and be arranged for any desired size. Extension dividers are of great use in filling in more or less by free hand drawing, details from some other map. Blue prints may be used to directly copy the larger maps.

While to the uninitiated the system here described may seem a complex one on account of the length of space required to describe the same, five minutes practice with some note book prepared for the purpose will make the beginner as expert as the one who may have used this system for years. The letters of the alphabet here suggested for use can readily

be secured from dictionaries, encyclopedias, grammars and elsewhere.

NOTES ON THE GEOLOGY OF SOUTHEASTERN IOWA.

By C. H. Gordon.

The surface geology of southeastern Iowa has received much attention from geologists owing to the favorable conditions this region offers for the study of the Subcarboniferous formations. The fact that certain localities within this region have furnished fossils in wonderful variety and abundance has given it special favor with palæontologists. The underlying strata, however, have received little or no attention. Having recently undertaken some investigations concerning the sub-driftrock-surface, certain facts relative to the deeper strata have fallen under the writer's notice which may be of sufficient importance to furnish an apology for this paper. Though the data derived from the records of deep wells are not of such nature as to be completely satisfactory, yet on the whole, the science of geology is under deep obligations to well drillers for information obtainable in no other way. Operations of this character having been pushed considerably of late in this section, either for the purpose of securing reliable supplies of water or to test for gas or oil, we have taken the opportunity to secure such records as were available. At Keokuk Mr. J. C. Hubinger has recently completed two wells, one 935 feet and the other 1,805 feet deep. The drillers are now at work on the third well and a fourth may be put down in the future. The wells are all located on the bluff overlooking the Mississippi, and the water is received in an artificial lake in the beautiful lawn adjacent to his palatial residence. From this lake the water is then carried in a chute down the face of the bluff about 130 feet where it is utilized in running two dynamos for furnishing incandescent lighting to the city. This method of securing water-power is certainly ingenious. The quantity of water obtained from the two completed wells is about 1,300 gallons per minute. The third will bring it up to 2,000 gallons. The record here given is presented with a considerable degree of confidence as the results so far have practical agreement in all the wells. The record of the well at Sigourney is given as published by the common council of that place. That from Ottumwa was furnished by Mr. J. A. Hamilton. Mr. H.

writes us that this well was put down to test for gas and oil and that the failure to find either—a result to be expected by those familiar with the stratigraphy of this region—was a great disappointment to the people of that place.

	KEOKUK,			OTTUMWA.			SIGOURNEY.		
		Thick.	*Depth.*		*Thick.*	*Depth.*		*Thick.*	*Depth.*
Surface.......	Bluff ...	25 ft..	25 ft	Drift	23 ft	23 ft	Drift....	98 ft	98 ft
	Boulder clay	3 "..	28 "						
St. Louis....	Limestone	5 "..	33 "	Limestone	23 "	46 "			
				Shale	14 "	60 "			
	Sandstone	5 "..	38 "	Sandstone	30 "	90			
	Limestone	12 "..	50 "	Limestone	14 "	104 "			
Keokuk—	Shale....	58 "..	108 "	Shale					
	Limestone	62 "	170 "	Limestone	116 "	220 "	Limestone	89 "	187 "
	Shale....	10 "	180 "				Shale....	2 "	189 "
Burlington—				Sandstone?	30 "	250 "			
	Limestone	110 "	290 "	Limestone	180 "	430 "	Limestone	132 "	321 "
	Shale (cal.)	65 "	355 "				Shale....	29 "	350 "
Kinderh'k—	Limestone	10 "	365 "	Limestone	15 "	445 "	Limestone	4 "	354 "
	Shale ...	195 "	560 "	Shale	160 "	605 "	Shale	252 "	606 "
Hamilton—	Limestone?	65 "	625 "	Limestone(?) mixed with			Limestone	229 "	835 "
Oriskany—	Sandstone (sandy)	20 "	645 "	Sand.....	200 "	805 "	Sandstone	41 "	876 "
Niagara—	Limestone	55 "	700 "	Limestone	150 "	955 "	Shale sandy	14 "	890 "
	Sandstone	37 "	737 "						
Maquoketa—	Shale.....	63 "	800 "				Shale.....	140 "	1030 "
Galena & Trenton	Limestone Sandy			Lime and			Shale (?) (sandy below)	25 "	1055 "
	below	140 "	940 "	Sandrock	90 "	1045 "	Limestone	113 ft	1168 "
St. Peters—	Sandstone	110 "	1050 "	Sandstone	93 "	1138 "	Sandstone	107 "	1275 "
L. Magnesian—				Slate......	20 "	1158 "	Shale.....	4 "	1279 "
	Limestone alternating			Limestone	100 "	1258 "			
	with Sandstone			Sandstone	122 "	1380 (?)	Sandstone?	609 "	1888 "
		755 ft	1805 ft	Limestone	697 "	2077 ft			

NOTE.—In some cases the determinations given by the drillers are evidently misleading; as, for example, in the Ottumwa well at 220-250 is given a sandstone which doubtless is the Upper Burlington, which might easily be mistaken for sandstone unless one were familiar with the rock. So also the classification in certain cases can only be made provisionally as where limestones of different formations follow each other, the driller gives it all as "limestone." In the main, however, the record may be relied upon.

Geologists will at once recognize some features in the above records not heretofore given in Iowa geology. At Keokuk and Sigourney, as also in Washington,[1] the Devonian is underlaid by a bed of sandstone which we were at first inclined to consider the representative of the Medina of the eastern geologists, but on further study believe it to be the Oriskany as found in Illinois and adjacent states. It is probably confined to the south and east part of the state. It is separated from the sandstone of the Niagara at Keokuk by a limestone somewhat arenaceous which probably constitutes the upper portion of that formation.

Another fact of importance brought out in the above records is the remarkable development of the Lower Magnesian series in this region. At Keokuk the drill passed 755 feet of this formation without completing it and at Ottumwa the record

[1] AMERICAN GEOLOGIST, Jan. 1888.

gives 939 feet which still seems short of the actual thickness of the series.

At Sigourney the drillers give 609 feet of sandstone but it is altogether probable it is the same as the others. At Keokuk the current of water was so strong that samples were not easily obtained, but at different times samples were secured, showing a brownish shaly limestone above sometimes white and fine-grained alternating with sandstone which was hard and calcareous in portions. Thickness of each division could not be made out. The lower part seemed to be cavernous, the drill dropping two feet at one point. The flow of water was increased at two places which doubtless represents the number of sandstones included. At Ottumwa the rock showed substantially the same characters. Mr. Hamilton says that the last 697 feet was "hard limestone full of holes, the sides of which are encrusted with a white substance evidently deposited by water. A piece of this rock about twice the size of a man's fist was brought up from a depth of about 1,700 feet having been caught in some way in the rope above the drill." It seems conclusive that the Lower Magnesian series has a much greater thickness in Iowa than has heretofore been supposed. As the Davenport well[2] shows 622 feet of this series, which is corroborated by the records above with an increase in thickness, the conclusion seems justified that the maximum thickness of this formation within the limits of Iowa can not be less than 1,000 feet. In the vicinity of St. Louis, Mo., it is nearly 2,000 feet in thickness.[3]

There is some probability that the Hubinger No. 3 now well under way will be continued through the Lower Magnesian series in the hope of finding more water in the Potsdam. It is greatly to be hoped this will be done as it will definitely settle the question of the thicknes of this series in Iowa.

A POCKET MAPPING INSTRUMENT.

By Alfred C. Lane.

What with compass, notebook and pencil, one hammer or possibly two, map, lunch and collecting bag and perhaps barometer, the field geologist is apt to realize too forcibly the meaning of the Latin term "impedimenta." The little instru-

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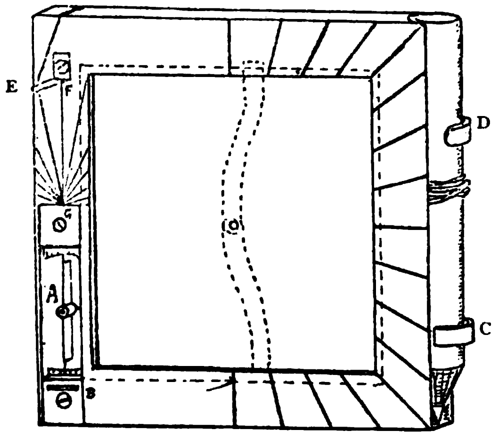
[2] American Geologist, Feb. 1889.
[3] Missouri Report.

ment I have to describe, which in default of a better word we might call a "geograph," has proved a handy consolidation of some of these instruments.

It consists of a frame (see figure *) like a picture frame with a removable back held in place by the spring shown in dotted line, as in a photographic printing frame. This frame is of any suitable size. The one I have been using is $5\frac{1}{2}$x7 inches, outside measurement, and will cover a couple of land sections with a broad margin, at a scale of 2 inches to



one mile. A larger one would be in many ways more convenient but this just slips into my pocket. At the lower left hand corner is an oblong compass box (A) with width enough to allow for a magnetic variation of several degrees and a stop (B) to lift the needle up when not in use.

The right hand side has a semi-circular groove, and from the back of the frame curve forward two strips of elastic brass, (C) and (D), D forming a trifle over a quadrant, C very nearly a semi-circle. The pencil is thrust through C and then pressed into D. A small rubber band is twisted three or four times around the pencil, which increases of course the pressure needful to press it into place, and prevents its falling out or rattling. I have never lost a pencil from the holder.

Above the compass on the left hand side is a sun-dial for determining true north, when the time o'day is known or vice versâ,—for regions of local attraction indispensable. From a small hole in the frame at G an elastic cord runs through a hole or notch near the top of a movable arm E which is hinged at F, and thence over the top of the frame in a slight groove to the back where it is fastened. When the arm E is

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The figure is drawn in crystallographic projection with the thickness and breadth of frame increased out of proportion to show the construction better.

erect, the < E G F should equal the latitude. Adjustment for different latitudes could be made both by a series of notches in the arm E and by having the base F adjustable so as to slide to and from G.

When not in use the arm E folds down, the cord contracts out of the way and nothing dangles as in the dial compass. But if F or E be changed the graduation of the dial must also be changed. If H is the number of hours before or after noon, P the point where at that time the shadow of the cord crosses the edge of the frame, m the projection of P on F G, we find mG—Pm is fixed,—by the formula $\frac{mG}{Pm} = \frac{\cot H}{\sin \text{lat.}}$

If it might be necessary to change the adjustment on a journey when tables are not at hand these two thumb-nail tables might be written on the back of the frame:

P.M.	A.M.	cot.H.
12	12	∞
1	11	3.732
2	10	1.732
3	9	1.000
4	8	0.577
5	7	0.268
6	6	0.000

To find latitude;—if latitude $=\lambda^\circ = c^\circ + \delta^\circ$ where δ is small, we have $\sin \lambda = \sin (c^\circ + \delta^\circ) = \sin c + \frac{\delta^\circ}{60} \cos c - \frac{\delta^2 \sin c}{7200}$; if we let $c = \underline{36}^\circ 50'$, $\sin c = .6$, $\cos c = .8$; and for the United States δ will be small and this formula nearly true.

$$\text{Sin lat} = \frac{6}{10} + \frac{4(\lambda - 36^\circ 50')}{300} \left[- \frac{(\lambda - 36^\circ 50')^2}{12000} \right]$$

Only the first two terms need be used.

The frame is further marked with heavy lines in front to indicate the courses which are most used by woodsmen and are easily platted with coördinate paper, as given in the table below.

The figures show graduation only on one side of the frame, but it is best to have it run all around.

On the back of the "geograph" is a simple clinometer,—a weighted string fastened on the pencil side. There is a protractor scale on the back about the point of fixture, and the pointed weight is shoved into a slot when not in use. A couple of small spirit levels set at right angles into the frame would improve it.

The geograph may be used in two ways. First with coördinate paper in the usual fashion of woodsmen. The side of the geograph being brought to point north, the rulings of the sheet of coördinate paper cut to fit the frame run the same way. The course which we wish to go being picked out from those marked on the frame, a sight is taken over and along it and pursued. Having gone that way as far as we want, preferably some number of paces which stands in a simple ratio to

that number in the first column (of the table below) which is in the same horizontal row with the chosen course, we can easily plat it from some chosen point, and thus continue. Several sheets of coördinate paper are always kept in the frame in case our course should lead us off the first one. At each stop we can fill in the topography accurately as the sheet and the country lie before us in the same position.

TABLE OF COURSES.

A run of	on a course N. E.	will carry as N.	and further E.	
103.+.07	14° +3′	100	25	76°- 3′
316.+.20	18°+25′	300	100	72°-25′
112. -.20	27°-26′	100	50	62°+26′
360.+.53	34°-19′	300	200	56°+19′
125. -.00	37°- 8′	100	75	53°- 8′
141.+.42	45°	100	100	45°
Paces.		E.	N.	N.E.

This table should be memorized or written on the back of the geograph.

Or secondly it may be used as a plane table, a strip of stiff colored card with a graduated edge or even a pencil, serving for an alidade. Point the card in the direction to be determined (keeping the side of the geograph pointing N.) and draw a line along it.

There are some other incidental points. If you have your maps cut up and mounted on linen to fit, they may be slipped in. It will save wear and dirt and enable you to orient your map in a moment. Moreover you can keep your course on the map, or on a sheet of tracing linen over it in the frame. Whenever it is needful to make or finish a run in wet weather tracing linen or oiled paper can be slipped over the map or coördinate paper and the notes continued. It is not a bad idea to make blue prints of maps for field work and for this the frame is useful.

Thinking that this geograph might be of use professionally to others than geologists,—woodsmen, explorers, prospectors, army engineers, etc., I have taken steps to have it patented. But if any geologist will order one from me specifying how he

wants it made, at about what cost, graduated or not, with or without spirit levels and dial, and of what size inside or out, I will send him one at its cost to me, following his directions as far as they go, as I am about to have some made. The main expense is in the compass. Mine cost about $8.00 of which $6.00 was for the compass. The graduation I did myself. By the quantity they will be cheaper, yet the price will have a wide margin of variation. If one does not want to put out much money, for many districts the dial might be omitted, and the graduation done at home, and an inexpensive compass used, though good enough work can be done to warrant a good compass.

State survey, Houghton, Michigan, August, 1889.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

The Neozoic Geology of southwestern Arkansas, [with map.] By ROBERT T. HILL, assistant geologist, U. S. geological survey. Vol. II of the annual report of the geological survey of Arkansas for 1888, in four volumes; By JOHN C. BRANNER, Ph. D. State geologist, Little Rock, 1888. 8vo. pp 290, with appendices.

This is a careful detailed report of one of the most important areas of the United States, where the unique Quaternary, Tertiary and Cretaceous phenomena of the South meet those of the West, and where all the Mesozoic and Cenozoic phenomena of the Southwest border upon the older Paleozoic continental outline.

The geographic position of the region is clearly defined and the whole southern region divided structurally into (1); an interior or older (Paleozoic) division where the structure is more consolidated, the streams more permanent, the altitude higher and hygenic conditions more propitious; and (2) into the newer (Neozoic) addition, in which the structure is unconsolidated, the country low, the drainage valleys wide and overflowing, and hygenic conditions proportionately malarial. The first of these is the southern industrial and small crop region, the latter the planting region, and their relation to the substructure is brought out throughout the work.

The northern limit of the newer or Neozoic continental addition in the region described is a remarkable system of mountains, (not to be confused with the Ozark system), which extends west from Hot Springs, with a few interruptions to the Pan Handle of Texas, and which has been the ancient shore line of all the Mesozoic and Cenozoic subsidences, more than five of which are clearly recognizable as shown in p 184. It is remarkable that this important orographic system has not hitherto been described.

The topographic features of the region south of these mountains is

that of an old base level, about 500 feet high, forming the flat-topped divides of the drainage system, and skirting the mountains for over 100 miles west, into Indian Territory, and thence south into Texas. It consists of the gravel debris of the Ouachita mountains, is of early quaternary age, and has planed off and covered the Eocene and Cretaceous strata, and, in turn has been grooved and partially destroyed by recent and late quaternary denudation, as recorded in the terraces, and deep cut drainage, some 250 feet below the Plateau-Gravel base level. The river systems of Arkansas and Texas are described, and classified into four sub-groups according to their origin and similarity. The Arkansas and Rio Grande rising in the Rocky mountains and circumscribing the region are of the first order, the Red, Brazos and Colorado of the second, and the Ouachita, Little Missouri, Trinity, Nuces, etc. of the third; while numerous minor streams of post quaternary origin are of the fourth.

Under the head of "Fundamental Stratigraphy" are defined, discussed, and named in appropriate local terms six distinct formations above the Paleozoic, which is the foundation of the whole group. These include over 3500 feet of strata seen, which is a modest estimate of the whole thickness, and are of lowest Cretaceous, upper Cretaceous, basal Tertiary, early and later, and recent Quaternary ages respectively. Each of these is described and sub-divided into approximate horizons and the exact sequence of every layer shown both structurally and chemically (see pp. 220-221), and its relation to the Mississippi region in the one hand and the Texas in the other set forth; while upon an appropriate map and sections their exact distribution is shown.

Each of these formations is of great interest, and Mr. Hill has succeeded in bringing them out clearly. The lowest or Trinity division of the basal Cretaceous, is especially interesting, in that it shows the exact relation of the base of the Cretaceous to the Paleozoic, and adds to our geologic section a most important horizon. These beds follow the Paleozoic parting west into the Indian Territory and eventually crossing into Texas to the south, following the topographic feature known as the upper cross-timbers of the latter state. They consist of sands and clays, with occasional adventitions layers of shell-breccia, (limestone), and contain a molluscan fauna paleontologically almost identical with the European Wealdan, associated with huge saurian bones and fossil plants which have not been studied. Prof. Hill writes that his assistant Mr. Taff, of the Texas survey, has measured over 1000 feet in thickness of this formation in his region.

The exposures of the limestone beds of the Comanche Series so greatly developed in the Texas region, stop short at the Arkansas-Choctaw line, and are exposed only in Arkansas in the depths of Little river, a mile or two from the border.

It is to the development of the upper Cretaceous, and the thorough discussion of that formation in Arkansas and Texas and its relation to

other areas, that the author devotes a greater portion of the work; and it is the first attempt at a thorough description of these beds. They tell a remarkable history in their faunal and chemical sequence. They are sub-divided into appropriate divisions and horizons, and the author shows that the uppermost arenaceous [or glauconitic division as they could better be called] is the southward continuation of the New Jersey Cretaceous below the middle marl bed horizon, and of all the Mississippi section except the Eutaw of Hilgard, (Tuscaloosa of Smith and Johnson). Below these glauconitic beds in Arkansas and Texas are nearly two thousand feet of *upper Cretaceous* marls, chalks, clays and sands, which have hitherto been erroneously correlated with the Hilgard section. The top of these upper Cretaceous beds has been eroded during the land epoch between the Cretaceous and Tertiary times, and of the Tertiary overlap. The most remarkable feature of these upper Cretaceous beds is the beautiful white cliffs of Little river. "These cliffs which have long been a landmark of the region are about 150 feet high, perpendicular and as white and almost as pure as the celebrated chalk cliffs of Dover." Their remoteness from lines of travel is probably the only explanation of their having so long been overlooked by American geologists. It is the remnant of a great area, which has clearly been eroded away during Tertiary and Quaternary times.

A chapter is devoted to the "Occurrence of chalk in the North American Cretaceous" in which the predominant chalky origin of the typical section of the American Cretaceous as seen in this northwestern region is shown, and it is asserted that "we have in a general manner "not only the equivalent of the upper, but also of the lower Cretaceous "beds of Europe, while chemical stratigraphical and microscopical "investigations prove conclusively that the culminating lithologic "character of each of the two grand divisions of the region are Creta"ceous (chalky) in fact as well as in name. In other words the great "mass of the Cretaceous rocks in the American as in Europe are, or "were, mostly composed of more or less chalky foraminiferous, infra"littoral sediments, and that the uppermost, or arenaceous beds of "New Jersey, Alabama, and the Northwest are only the northward ex"tension of the upper and shallower beds, and not representative of "the whole.

Following upon these facts, and "without endeavoring to establish ex"act synchronism of minute horizons, the writer has shown much "closer relations between these American formations and those on the "opposite side of the Atlantic than the accepted canons of American "geology allow. This has not been done to satisfy any preconceived "hypothesis, but solely because the geologic facts of this southwest re"gion admit of no other conclusion.

The volume is full of new paleontological data upon the geographic distribution and association of species, while seven plates of new fossils are given illustrating the molluscan fauna of the Trinity division. An innovation is made whereby over 40 figures are made of a single oyster,

showing every possible variation, which will save future confusion. An interesting table on page 166 shows the stratigraphic distribution of all the Cretaceous *Ostreidæ* of the region, and at a glance, throws entirely new light upon these important forms. In chapter XV, two typical species, *Gryphæa pitcheri* Morton, of the lower Cretaceous, and *Exogyra costata* Say of the upper Cretaceous are discussed, and the remarkable controversy concerning the former, which for years has occupied American geologic literature is reviewed and the confusion surrounding this important species, dispersed.

It is impossible to review at length the data here presented for the first time of the detail of the basal Tertiary and the Quaternary formations. They describe these features as they are, and throw new light upon them. They are as valuable as the Cretaceous discussion, and give the first local description and section ever published from that region.

Part II of the report, in the writer's opinion is as important as the first, and consists in a discussion of the economic features. It contains a scientific treatise upon the origin and classification of soils and describes in the language of the people every geologic soil of the region, transported or residual, and points out clearly their defects or excesses, and how they can be remedied, by natural means, i. e. the use of the valuable and untouched beds of gypsum, chalk and greensands, in which the volume shows that the region abounds. Inasmuch as nine-tenths of the soil of Arkansas is deficient in these very elements, these facts are of incalculable value to the agricultural interests of the state. Another remarkable economic fact is the perfect analogy of conditions for making Portland cement, existing between this region and the original seats of that industry in England, which is further brought out in an appendix by Dr. Branner.

The chemical analyses, by Dr R. N. Brackett, are of importance to the geologist, for they give both the composition of the original structure and the soil derived from it, thereby permitting the general character of geologic areas to be determined, and obviating largely the necessity of analyzing every individual farmer's field. Besides these analyses are arranged in a systematic geologic sequence so that great light is thrown upon the geologic origin of the strata.

The print of the work is excellent considering the conditions under which it is done, but the book has many typographic errors, probably due to lack of oversight by its author. Altogether the work is a creditable addition to the geologic literature of the country, and is especially valuable as a key to an almost unknown region and to a much discussed section of American geology.

Solar Heat, Gravitation and Sun-spots. J. H. KEDZIE.*

Having stated his conception of the nature and origin of the heat of the sun, the author fills the rest of the volume with arguments and illustrations to prove its applicability and validity. His first is a

* See page 181 for the commencement of this review.

general and sweeping *ad captandum* presentation of the case. Thus: "If all the heat from an infinite number of stellar suns has been pouring into this universal ether for indefinite, if not for infinite ages, if it has all been conserved and is still in existence, if there is no other universal ether into which this heat can make its escape, if neither this universal ether nor its included spheres are becoming hotter by the reception of this heat, then it seems to me that I am justified in saying that this heat must change into other forms and disguises. The forces of nature masquerade grandly; sometimes in the ineffable light and heat of the sun, sometimes in the darkness and silence of night, but none the less real in the latter case than in the former."

On the acceptance of the idea that the sun's radiations are converted into other forms of energy on passing outward to the surrounding spaces, several necessary conditions result, which require plausible further illustration and explanation. 1st. The method and cause of such change, and likewise the method and cause of the reverse change to "despecialized heat" again on their return to the sun. 2nd. The actual and recognized changes which the planetary system has undergone, under the principles of the nebular hypothesis of LaPlace, (which is accepted by the author) which have brought some portion of the energy of the ethereal emanations into specialized conditions and stored it up in other forms in the planets.

In regard to the first change in the nature of the sun's emanations, Mr. Kedzie satisfies himself, and reasonably supposes the reader to be satisfied, with showing the possibilities and need of the change assumed, without any demonstration of the actual cause and method. The cause and method are the secrets of nature which she but scantily reveals. They are the same, however, as the causes and methods of conversion of one force into another which are feebly employed and exemplified in the physical or chemical laboratory; though instead of being cramped and forced by conventional appliances and confined in narrow and unnatural limits, with exceptional environment, these changes, where they take place under nature's hand, operate so spontaneously, and smoothly, that their effects are invisible, and are taken up by the harmonious, ineffable sympathies that pervade the forces of the universe in their sway over matter, and are diffused through space by media that the human senses do not apprehend. In this manner the author would suppose the wave which started from the distant Sirius as a wave of heat and light becomes converted to light only, to our senses, before it reaches the earth, while that from our sun, not having so far to travel, reaches us in the form of light and heat, gravitation and actinism, and before it reaches Sirius is of the same character as the ray of Sirius to us. Some portion of the sun's energy, when sent into space as waves of ether, is converted also into gravitation, the impact of the waves from all portions of celestial concave on any planet, resulting in that motion which we attribute to gravitation. Other change is seen in the promotion of chemical combinations, electricity, magnetism, and even vital energy,

in the various inhabited spheres. This the author claims under the law of the "conservation of force;" and that the sum total of all the sun's radiations, and the radiation of all suns, again are restored to them he assumes under the simple law of the boy's axiom, "whatever goes up must come down." The sum total of the energy of the universe neither gains nor loses. The ether can not retain it; it simply transmits it. But it can only transmit it to a receiver, and the heavenly bodies are the only receivers.

Despecialized heat, however, which starts from the sun, returns as specialized energy. The author supposes the sun's surface to be the place where it is again despecialized. It returns as mechanical energy (or gravitation), as electricity, and perhaps as other forces, and "precipitating themselves upon the myriad points of the photosphere they turn to light and heat almost exactly as electricity does in the electric lamp; that is by the excitation of and resistence to electric currents. I should lay more stress on this mode of transformation of energy were it not that every dabbler in science invokes the aid of electricity to solve every mystery. Still the abuse of one of the great energies of nature should not deter us from assigning it to its proper place in the grand economy of the universe." The author then enforces this thought by instituting a comparison between the electric spark of two approximate carbon points and the incandescent carbon clouds of the photosphere, where the particles are divided to the last degree of minuteness and offer every inducement to the action of electricity.

As to the second necessary condition mentioned above, the author accepts the nebular hypothesis, but while allowing for the cooling of the sun, the planets and all the satelites, he insists that no heat is lost. It is simply reduced to specialized conditions. One of the first specialized forces, subsequent to the nebulous condition wherein all energy is expressed in one word—heat—was mechanical motion in the form of immense vortices, resulting in some condensation of the volume and some cooling of the substance of the nebulous mass. This vortical motion continued has resulted in the partition of the mass into suns, and into systems. Then came cohesion, which further reduced the common stock of heat. Then gravitation became apparent, and chemical action, electricity, magnetism, and lastly *vis viva*, each in its proper order, accompanied by cooling and contraction until the present equilibrium was attained. This specialization of energy from the all-embracing form of force, heat, the author claims, is not a loss of heat, only a change of its form of existence as energy, but this is a play on the word. As heat it does not longer exist, but as energy it continues to act. The author technically seems to fall into the inconsistency of allowing cooling to go on, but denies the loss of heat by the cooling body. We understand, however, that he combats the idea that the heat radiated by the cooling nebulous mass is lost to the emergent planetary system, and maintains that it is preserved in other forms of energy.

A chapter is devoted to "potential energy," or that stored-up force which some physicists have dressed up in mathematical formulæ, ready to act when the proper circumstances arise. If there be such energy in the universe it will profoundly affect the calculations of the author, which are based on the sole and comprehensive source represented by primal heat. He shows that all instances of what is styled potential energy are resolvable into kinetic force, and that really potential energy is a myth, and can play no part in a rational theory of solar heat.

Under the definition of energy as *matter in motion*, and in compliance with the law of conservation of force, "energy is generated nowhere, it is lost nowhere, it is confined to no place, it travels endlessly from world to world and from sun to sun, it never tires, it never rests, it never begins, it never ends, it never increases, it never grows less. It is at once the symbol of omnipotence and of eternity. The universe can never, never, never run down." The dissipation of energy is therefore true only in the sense that energy may be diffused, and may take on other forms.

[TO BE CONTINUED.]

RECENT PUBLICATIONS.

1. *State and Government reports.*

Geological survey of Arkansas, Annual report for 1888, vol. ii. The Neozoic geology of southwestern Arkansas, by Robt. T. Hill, with appendices, The northern limits of the Mesozoic rocks in Arkansas, by O. P. Hay, and On the manufacture of Portland cement, by John C. Branner.

2. *Proceedings of Scientific societies.*

Bulletin of the Proceedings of the Colorado Scientific Society, vol. III. Part 1, 1888, contains the following geological papers: Preliminary notes on the Eruptions of the Spanish peaks region (with map) by R. C. Hills; Colorado Volcanic Craters, by P. H. VanDiest; Notes on some unusual Occurrences of Galena Crystals, by F. F. Chisolm; Mineralogical Notes, by W. F. Hillebrand; The Quaternary of the Denver Basin, by Geo. L. Cannon Jr.; The Genesis of Ore Deposits, by Richard Pearce. Two Sulphantimonites from Colorado, by L. G. Eakins; Notes on the Ore occurrence of the Red Mountain district, by T. E. Schwarz; On some Stratigraphical and Structural Features of the country about Denver, Colorado, by Geo. H. Eldridge; The Denver Tertiary Formation, by Whitman Cross; On the Tertiary Dinosauria found in Denver Beds, Geo. L. Cannon Jr.; The recently discovered Tertiary Beds of the Huerfano River basin, Colorado, (with map) by R. C. Hills; The field for original Work in the Rocky mountains, by Pres. R. C. Hills.

4. *Excerpts and individual publications.*

Bulletins of the Washburn college Laboratory of Natural History, Topeka, Kansas, 1884-1889 contain the following geological papers:

Notes on Localities of some interesting Minerals. By *J. C. Cooper.* Jan. 1885.

Notes on the region of Crooked creek, Kansas. By *F. W. Cragin.* Jan. 1885.

Notes on the Geology of southern Kansas. By *F. W. Cragin.* Apr. 1885.

Further Notes on the Dakota Gypsum of Kansas. By *F. W. Cragin.* May, 1886.

Notes on some Rare Minerals of the southwest. By *J. C. Cooper.* July, 1886.

Preliminary Notes on a Study of Atrypa reticularis. By *W. R. Lighton.* Oct. 1887.

A new species of Unio from Indian territory. By *F. W. Cragin.* Oct. 1887.

Geological Notes on the Region south of the Great Bend of the Arkansas. By *F. W. Cragin.* Feb. 1889.

Check list of the invertebrate fossils from the Cretaceous formations of Texas; accompanied by notes on their geographic and geologic distribution. By *Robt. T. Hill.* Univ. of Texas—School of Geology. Austin. 8vo. 16 pp.

Palæontology of the Cretaceous formations of Texas. Part I. Published in installments. By *Robt. T. Hill.* Austin. Univ. of Texas —School of Geology. Roy. Oct. pp. 6, 3 plates.

The North American Mesozoic: Address of *Prof. Charles A. White,* vice president, Sec.E, A.A.A.S. Toronto. August, 1889.

Remarks upon sedimentation in the Cincinnati group. *Jos. F. James. Cin. Soc. Nat. Hist.* April, 1889.

Contributions to the Mineralogy of Maryland. *Geo. H. Williams.* From *Johns Hopkins University Circular No. 75.*

On the discovery and significance of stipules in certain dicotyledonous leaves of the Dakota rocks. *F. H. Snow. Trans. Kansas Acad. Science.* 1888.

Salt: its discovery and manufacture in Kansas, with suggestions for its use in agriculture. By *Robert Hay.* Sixth biennial Report. *Kan. State Board of Agr.*

5. *Foreign publications.*

Structures et classifications des Roches Eruptives, par A. Michel Lévy pp, 82. Paris, 1889.

The present state of the Archæan controversy in Britain. By Charles Callaway. Ex. from the *Geol. Mag.* Dec. III. vol VI. No. 301, 1889.

Limestone District, part of the Palmer Gold field (with map). By Robert L. Jack, Government Géologist, Queensland.

Sur un gisement francais de melaphyres à enstatite, par M. A. Michel Lévy. Mars, 1889. Paris.

Les Géologues et la Geologie du Jura, jusqu'en 1870, par Jules Marcou. Ext. *Mem. de la Société 'd Emulation du Jura,* pp. 84. Lons-Le-Saunier, 1889.

PERSONAL AND SCIENTIFIC NEWS.

The American Association for the Advancement of Science held its third Canadian meeting at Toronto commencing August 27th. The two previous meetings were those at Montreal in 1857 and in 1882. The University buildings afforded ample space and agreeable surroundings for the meetings. There was a free luncheon daily, as well as drives and garden parties and excursions to Niagara, Muskoka and Sudbury. The attendants of members was not large, but included an unusual number of the older and more eminent members, no less than eight of the past presidents being present—Dana, Hall, Newberry, Barker, Dawson, Young, Newton and Morse. Canadian members were well represented, there being twenty-nine from various parts of Canada, not reckoning forty-five from Toronto. From a scientific point of view the meeting was successful, but not remarkable for anything very new or striking, though there were many important and useful papers, especially in anthropology, geology and biology. The two evening lectures of the meeting were on "Niagara," by G. K. Gilbert of Washington and "Four weeks in the desert of Mount Sinai," by Dr. H. Carrington Bolton of New York. Both were interesting, well illustrated and listened to by large audiences. In other respects it was probably one of the most agreeable meetings of the thirty-eight which the American association can now reckon. The following is a summary of the statistics as given by the permanent secretary, Prof. Putnam, who received the well merited thanks of the association, and was re-appointed for five years:—"There were 424 members and associates registered; of these 45 were from Toronto, 29 from other parts of Canada, and the balance from the United States. There were 201 new members and seventy-two fellows elected. There were 199 papers read and 227 submitted. There was placed in the public library at Toronto a full set of the publications of the association, and the library has been placed upon the list for all future volumes. The invested funds of the association now amount to $4,700. The income of this sum was devoted to scientific research, and a lady member had sent a check for $500 to swell that amount."

Prof. T. C. Mendenhall of Washington was president at the Toronto meeting, and Prof. Geo. L. Goodale, successor to Dr. Asa Gray at Harvard, was elected president for the next meeting, which is to be held in Indianapolis.

Section E was presided over by Dr. C. A. White of Washington, who delivered an opening address on "The North American Mesozoic." The secretary of the section was Prof. J. C. Branner of Little Rock. The following papers were read before section E:

Topographic types of northeastern Iowa.—25 min.—By W. J. McGee.

The lake ridges of Ohio and their probable relations to the lines of glacial drainage into the valley of the Susquehanna.—30 min.—By G. F. Wright.

(*a*.) The moraines of the Wabash—Erie region. (*b*.) The Irondequoit glacier.—15 min.—By C. R. Dryer.

Glacial phenomena of northern Indiana and northeastern Illinois.—20 min.—By Frank Leverett.

The attractive scenery of our own land.—20 min—By A.S. Bickmore.

The mastodon of Kent and what we know about it.—20 min.—By Ed. Jones, Esq.

On certain remarkable new fossil plants from the Erian and Carboniferous, and on the characters and affinities of the palæozoic gymnosperms.—20 min.—By Sir Wm. Dawson.

Mammoth cave.—20 min.—By H. C. Hovey.

The Devonian system of North and South Devonshire.—25 min.—By H. S. Williams.

The reality of a level of no strain in the crust of the earth.—30 min.—By E. W. Claypole.

The geological position of the Ogishke conglomerate.—30 min.—By Alexander Winchell.

The origin of gneiss and other primitive rocks.—15 min.—By Robt. Bell.

Observations on the trap ridges of the East Haven (Conn.) region.—30 min.—by E. O. Hovey.

On a possible chemical origin of the iron ores of the Keewatin in Minnesota.—20 min.—By N. H. Winchell and H. V. Winchell.

Notice of some Zircon rocks in the Archæan highlands of New Jersey.—8 min.—By F. L. Nason and W. F. Ferrier.

Trap dikes in the region about lake Champlain and the Adirondacks.—10 min.—By J. F. Kemp.

Field studies of hornblende schist.—10 min.—By C. H. Hitchcock.

Remarks on the Cretaceous of northern Mexico.—10 min.—By C. A. White.

A classification of the topographic and geologic features of Texas, with remarks upon the areal distribution of the geologic formations.—20 min.—By R. T. Hill.

The Eagle Flats—formation and the basins of the trans-Pecos or mountainous region of Texas.—5 min.—By R. T. Hill.

The ancient volcanoes of central Texas.—5 min.—R. T. Hill and E. T. Dumble.

The geology of the Staked Plains of Texas, with a description of the Staked Plains formation—5 min.—By R. T. Hill.

The geology of the valley of the Upper Canadian from Tascosa, Texas, to the Tucumcari mountains, New Mexico, with notes on the age of the same.—10 min.—By R. T. Hill.

Note on the mapping of the Archæan, northwest of lake Superior.—10 min.—By A. C. Lawson.

On the structural and chemical differentiation of certain dykes of the Rainy lake region.—20 min.—By A. C. Lawson.

Natural gas in Fredonia, N. Y.—15 min.—By H. T. Fuller.

The petroleum belt of Terre Haute—10 min.—By C. A. Waldo.

Preservation of glaciated rocks in Worcester, Mass.—5 min.—By H. T. Fuller.

Two new faunas from the lower Cretaceous formation of Texas. (*a*) Caprina limestone fauna. (*b*.) The Shoal Creek limestone fauna.—5 min.—By R. T. Hill.

On the origin of the diagonal trends in the earth's crust.—15 min.—By D. S. Martin.

Casts of Scolithus flattened by pressure.—5 min.—By A. Wanner.

Origin of boulder pavements and fringes.—10 min.—By J. W. Spencer.

Section of the Maquoketa shales in Iowa.—10 min.—By J. F. James.

The history of the formation of the Great Lakes.—20 min.—By J. S. Newberry.

THE GEOLOGICAL SOCIETY OF AMERICA held its first meeting for scientific purposes at Toronto, August 28th, in conjunction with the American Association for the Advancement of Science. Section E adjourned one day for the purpose of attending this meeting. After an opening address by president James Hall, the following papers were read:

Areas of continental progress in North America, and the influence of those areas on the work carried on in them.—30 min.—James D. Dana.

Some suggestions regarding the sub-division and grouping of the species usually included under the generic term *Orthis*, in accordance with external and internal characters and microscopic shell structure.—James Hall.

On new genera and species of the family Dictyospongidæ.—James Hall.

The strength of the earth's crust.—30 min.—G. K. Gilbert.

On the origin of normal faults and the structure of the basin region.—20 minutes.—Joseph LeConte.

Boulder belts distinguished from boulder trains; their origin and significance.—20 min.—T. C. Chamberlin.

Study of a line of displacement in the Grand Canon of the Colorado, Arizona.—20 min.—C. D. Walcott.

Trap dikes near Kennebunkport, Me.—20 min.—J. F. Kemp.

The Sylvania sand in Cuyahoga Co., Ohio.—20 min.—P. Neff.

THE THIRD ANNUAL SESSION OF THE IOWA ACADEMY OF SCIENCES was held at Des Moines, Sept. 5, and was well attended. The society received several new members and gives promise of being a successful state organization. It is proposed in the future to have two classes of members, viz. *Fellows* who are actually engaged in original work, and *Members* who are not. Prof. F. M. Witter was chosen president for the coming year, and Prof. R. E. Call remains Secretary-Treasurer. Prof. J. E. Todd gave the retiring presidential address, on *The Mission of Science.* The following geological papers were read:

On the fossils of the Keokuk beds in the vicinity of Keokuk, Iowa, C. H. Gordon.

On the geology of eastern Arkansas, R. Ellsworth Call.

On the crystalline rocks of Missouri, Erasmus Haworth.

Observations on some Keokuk species of Agaricocrinus, C. H. Gordon.

PROF. ARTHUR WINSLOW, OF THE GEOLOGICAL SURVEY OF ARKANSAS, Little Rock, has been appointed state geologist of Missouri.

PROF. JOHN C. SMOCK, ALBANY, has recently made a special visit to the Alaskan glaciers, and observations on the drift phenomena on some parts of the Pacific coast in Washington, as well as on the gorge of the Mississippi between Minneapolis and Fort Snelling. These will be used in some comparative

studies contemplated on the drift of New York state, in connection with his official duties in the New York state museum.

PROF. R. D. SALISBURY, OF BELOIT, WISCONSIN, recently made a careful examination of the plan and equipment of the new Science Hall and Museum of the Minnesota State University, Minneapolis.

COL. FIELDING BURNES, brother of the late Representative Burnes of Missouri, has resigned the position of special disbursing agent of the U. S. geological survey.

MR. D. W. LANGDON, JR., who has been for a number of years connected with the Alabama geological survey, has entered upon the duties of geologist and consulting mining engineer of the Chesapeake and Ohio railway, with headquarters at Richmond, Va.

DR. H. M. CHANCE, has returned from the Choctaw Nation, Indian Territory, where he made an extended examination of Choctaw coal lands. Dr. Chance has opened an office in Philadelphia, and his permanent address hereafter will be 418 Drexel Building.

MR. G. E. BAILEY HAS BEEN APPOINTED PROFESSOR OF METALLURGY at the Dakota School of Mines, Rapid City, to succeed Prof. H. O. Hofman.

THE FAMILIAR EXPERIMENT of setting roofing-slates on edge upright in a dish of water, and noting how far the water ascends by capillary attraction in the substance of the slate, is one of the best tests that can be made. In a good slate the water should rise only slightly above the surrounding surface. A slate which draws up the water to a considerable hight should be avoided as likely to be destroyed by frosts and weathering. *American Architect.*

ALLOTROPIC FORMS OF SILVER. According to M. M. Carey Lea, in the *American Journal of Science*, June, "Silver is capable of existing in allotropic forms possessing qualities differing greatly from those of normal silver. There are three such forms, or rather three modifications of one form, differing from each other in many respects, but all more nearly related to each other than any one of them to normal silver. One of these forms is soluble in water, passing readily to an insoluble form, and this last may, by the simple presence of a neutral substance exercising no chemical action upon it, recover its solubility. Another form closely resembles gold in color and lustre. These allotropic forms of silver are broadly distinguished from normal silver by color, by properties, and by chemical reactions. They not improbably represent a a more active condition of silver, of which common, or normal, silver may be a polymerized form. Something analogous has already been observed with other metals, lead and copper."

THE EIFFEL TOWER. In the *New Review* Mr. Eiffel states

his purpose in constructing this tower. "I desired to show, in spite of my personal insignificance, that France continued to hold a foremost place in the art of iron construction, in which from the earliest days her engineers have been more particularly distinguished, and by means of which they have covered Europe with the creations of their talent. Doubtless you are not ignorant that almost all the great engineering works of this nature, in Austria, Russia, Italy, Spain, and Portugal, are due to French engineers; and the traveller discovers with pride, as he passes through foreign countries, the traces of their activity and their science. The tower, 1,000 feet high, is, before every thing, a striking manifestation of our national genius in one of its most modern developments; and this is one of the principal reasons for its existence. If I may judge by the interest which it inspires, abroad as well as at home, I have reason to believe that my efforts have not been unavailing, and that we may make known to the world that France continues to lead the world, that she is the first of the nations to realize an enterprise often attempted or dreamed of; for man has always sought to build high towers to manifest his power, but he soon recognized that the laws of gravity hampered him seriously, and that his means were very limited. It is owing to the progress of science, of the engineer's art, and of the iron industry, that we are enabled to surpass in this line the generations which have gone before us by the construction of this tower, which will be one of the characteristic feats of modern industry."

It is said that only three of the rarer metals are regularly produced in this country. These are aluminum, iridium and platinum. Most of the rare metals are imported from Germany, although many of their compounds occur more abundantly in North America than elsewhere on the globe. Gallium, as quoted in price lists of rare metals, commands the highest price, being worth $140.00 per grain. It is doubtful if the total production of this mineral since its discovery would amount to one hundred pounds. Vanadium and glucinum come next in order of value. Zirconium might be obtained from the zircons of North Carolina, but at present the supply all comes from Europe.

At a meeting of the Russian Mineralogical Society, K. D. Chrustschoff, it is said, demonstrated the existence of a new metal which he has just discovered and named "russium." The metal approximates closely in its properties to thorium, and its existence was predicted by Mendeléeff.

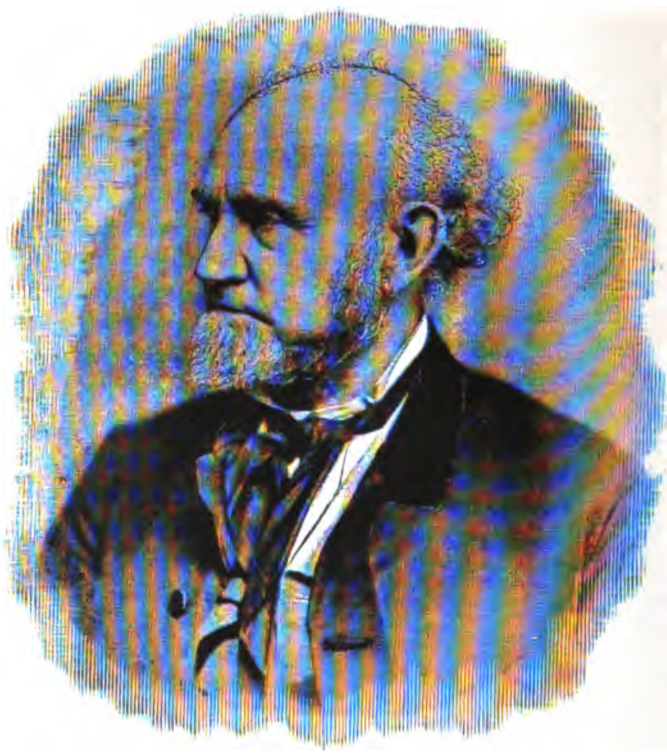
According to Prof. J. E. Todd the Dakota sandstone of the Cretaceous, supplies the main source of artesian water for the numerous flowing wells throughout all South Dakota.

North American Geology and Palaeontology is the title of a large work by S. A. Miller of Cincinnati Ohio, now in the

course of publication and expected to be ready for delivery by the 1st of November. The book will be Royal Octavo about 800 pp. in brevier type, with two columns on a page. About one hundred pages are devoted to definitions and laws of geology, stratigraphical geology and the laws of nomenclature. The great body of the work consists in a definition of all palæozoic genera with the etymology of the words, the name of the type species and place of publication, and the illustration of nearly all the genera, with lists of the species which have been described. Some genera are illustrated by a single figure of the type species or a typical species, and others have several figures to show the generic characters. The work will be indispensable to every geologist, and the author believes it alike serviceable to the beginner whether at home or at school. It will be sold at $5.00 a copy.

After the Late Meeting of the American Association for the Advancement of Science, at Toronto, an excursion to the area of the Huronian rocks in the vicinity of Sudbury was given by the Toronto Local Committee. This party was under the special guidance of Director A. R. C. Selwyn and Dr. Robert Bell, of the geological survey of Canada, and embraced, besides several ladies and some botanists and entomologists, the following geologists; Prof. G. C. Broadhead, Columbia; Dr. E. W. Claypole, Akron; Prof. C. H. Hitchcock, Hanover; Dr. E. O. Hovey, Waterbury; Dr. A. C. Lawson, Ottawa; Prof. E. W. Morley, Cleveland; Dr. A. Winchell, Ann Arbor, and Prof. N. H. Winchell, Minneapolis. The party numbered twenty-three and returned to Toronto, Saturday, Sept. 7th, whence they dispersed again to their respective homes.

This trip was remarkable not only for the marked interest that centers in the Huronian system of Canada, and the differences that have arisen as to its nature and stratigraphic position, but quite as much for the contrast it presented to the explorations made by the early geologists, Alexander Murray and Sir Wm. Logan, in the same region in the later thirties and early forties of this century. Those trips were arduous and dangerous, made in canoes or on foot, with a few Indians and laborers to carry along what food and instruments the work required. At night the party slept on the ground, sheltered only by a small tent or by a clump of bushes, or rolled up alone in their individual blankets. This trip was made in a parlor and sleeping car of the Canadian Pacific railway, in which the party found not only means for rest and sleep at night, and storage and transportation for instruments and specimens, but also the enlivening company and conversation of ladies. The car was drawn by a special steam engine, and was stopped wherever and as long as, the geological features of the region invited.



Chas. C. Whittlesey

THE

AMERICAN GEOLOGIST

VOL. IV. NOVEMBER, 1889. No. 5

CHARLES WHITTLESEY.

By ALEXANDER WINCHELL.

To the generation now passing away the name of colonel Whittlesey was a familiar sound; and his high, noble and benevolent physiognomy was a genial and inspiring vision in the circles of intellectual life. He was the moving spirit in numerous enterprises of science, literature and industry; his intelligence was many-sided, and diverse in the direction of its activity; his earnest life was prolonged almost to the limit of four-score years, and he established himself firmly in the regards of an extraordinary number of acquaintances, friends, and admirers. He achieved many important results which will perpetuate his memory as long as civilization endures; and yet adversities of fortune prevented his accomplishment of all that he aspired to, or all that he was fitted to achieve with honor and usefulness. Few have passed from active life more widely mourned or more profoundly venerated.

Charles Whittlesey was born in Southington, Connecticut, October 4, 1808.[1] He was the son of Asaph and Vesta (Hart) Whittlesey, who settled in Ohio in 1813. Asaph was descended from John, who arrived in America about 1650. He died in

[1] Most of the biographical data of the present sketch are taken from the "Memorial of Colonel Charles Whittlesey" drawn up by the honorable C. C. Baldwin of Cleveland, and published as Tract No. 68 of the Western Reserve Historical Society, pp. 406-434.

Tallmadge, Ohio in 1842, after spending twenty-nine laborious and adventurous years in laying the foundations of that civilization of which Ohio is so justly proud to-day, after the lapse of three-quarters of a century. He served his fellow-citizens as justice of the peace and postmaster, from the date of his arrival in Ohio to nearly the close of his life. Asaph was brother of honorable Elisha Whittlesey, a lawyer of Canfield, Ohio, ensign of a military company in 1808, and soon after captain; a soldier in the war of 1812, rising to the rank of brigade major and inspector, and serving eight terms as member of congress, and for many years first comptroller of the national treasury.

The stern and rugged virtue and intelligence of the father blended with the refinement and high ideals of the mother in the character of the son Charles. Reared in the American wilderness, seldom with a full sense of security from murderous savages, pressed daily by the relentless necessity of contributing as he might to the earning of the family's livelihood, Charles still possessed the industry and the aptitude requisite for securing early headway in a thorough education. At four years of age he began school at Southington; at five he sat in the log school-house at Tallmadge; at eleven he entered the newly completed academy, working on the farm in the summer until he was nineteen. At this age he became a cadet at West Point. Graduating in 1831, he became brevet second lieutenant in the fifth United States infantry, and in November started to join his regiment at Mackinac. He was detained for a winter's duty, however, at Fort Gratoit, and in the spring was assigned to the post at Green Bay. Resigning from the army at the close of the Black Hawk war, he opened a law office in Cleveland, and became part owner and co-editor of the *Whig and Herald*, until 1837. Public interest in geological surveys was now rapidly rising; and colonel Whittlesey had lent his influence as a journalist, to the dissemination of public interest in Ohio. Professor William W. Mather was placed in charge of the survey in that state, and among others associated with him was colonel Whittlesey, who was assigned to duty as topographer, geographer, and structural geologist. The survey, however, ceased to exist at the end of two years, and thus began that wasteful no-policy which the government of incompetency has since pursued in so many states. The

meagre and provisional statements contained in two annual reports were alone preserved; but the full elaboration of the results, even of two years work, by the highly competent corps of geologists enlisted, was totally lost to the Commonwealth. True, the State was then in its infancy; and the science itself had scarcely advanced beyond the infantile stage; and one may, perhaps, feel less surprise that the undertaking was abandoned than that it had been deliberately begun. "Fifty years since," wrote colonel Whittlesey in 1884, "geology had barely obtained a standing among the sciences, even in Europe. In Ohio it was scarcely recognized. The state at that time was more of a wilderness than a cultivated country, and the survey was in progress little more than two years. It was unexpectedly brought to a close, without a final report. No provision was made for the preservation of papers, field-notes and maps." And yet, one who knows what was accomplished by that early survey, and has watched the later developments of industry and civilization in Ohio, understands well that even such an incomplete survey has been worth many times its cost to the State.

During his connection with the survey, and during the two following years, colonel Whittlesey gave much attention to the ancient earth-works in the state, and may be said to have completed an examination of them. It was fortunate for American archæology that a student so competent was led to devote his efforts to the subject while yet the relics of the aboriginal race remained comparatively intact.

In 1844 he made an agricultural survey of Hamilton county. The same year the information was spread abroad that the geological investigations in Michigan had disclosed the existence of large deposits of copper in the Upper Peninsula. One of the companies organized in Detroit for explorations in that region engaged colonel Whittlesey as geologist. The exploring party coasted from the Sault Ste. Marie to the present site of Marquette. The ores of iron observed in abundance, had little value at that time, in consequence of the difficulties of transportation. The party pushed on to Copper Harbor, and thence to the Ontonagon region, wearied by labors, imperiled by winds and waves, but always sustained by the hope of rich discoveries. It was on this shore that Dr. Houghton lost his life in 1845. A life-like account of this journey was pub-

lished by colonel Whittlesey, in the *National Magazine* of New York, entitled, "Two Months in the Copper Regions."

From 1847 to 1851 inclusive, he was employed by the United States in the survey of the country around lake Superior and the upper Mississippi, with reference to mines and minerals.[2] Subsequently he spent much time in the mineral district of the lake Superior basin. The wild life of the woods, threading the stream with voyageurs and sometimes without a guide, was full of attraction for him. He was not, however, a rude hunter, nor a random explorer. He studied the forest as he advanced; he noted the topography, he measured the rock-masses and preserved in diagrams the knowledge of their attitudes and superpositions; devoting in all, fifteen seasons to the trying experiences of exploration in a country presenting all the hindrances and hardships of one of the most difficult and trying districts of any part of the earth.

In 1849, 1850 and 1858, he explored the valley of the Menominee river from its mouth to the Brulé. He was the first geologist to explore this "South Range."[3] He examined the north shore of lake Superior from the present site of Duluth eastward one hundred miles; and his examinations extended westward along the St. Louis river, to the neighborhood of the national boundary. His observations in Minnesota were published by the State in 1866.[4]

In 1858 and 1859, he was employed by authority in the prosecution of geological surveys in Wisconsin. He had been the first to make scientific observations worthy of recognition in northern Wisconsin, while connected with Dr. D. D. Owen's national survey, in 1848. In 1860, he was again invited by state authority to continue work in the same region, and made to professor James Hall a report on Ashland, Bayfield and Douglass counties which has never been published—the survey having been interrupted by the war.

[2] Owen, Geological Survey of Wisconsin, Iowa and Minnesota, pp. 425-473.

[3] Wisconsin Geological Report, III, 490, 679.

[4] Report of colonel Charles Whittlesey on the mineral region of Minnesota, 8vo, 52 pp. close type, with wood-cuts. "This little pamphlet contains much information concerning the northern part of the state not to be found in any earlier publication." (Geological Survey of Minnesota, final report vol. I. p. 99.)

The first sounds of war diverted colonel Whittlesey's attention toward a different field of activity. Having been educated a soldier, he felt that he owed his services to his country whenever a national emergency arose. He became a member of one of the military companies that tendered their services to president-elect Lincoln when he was first threatened in February, 1861. He became quickly convinced that war was inevitable, and urged the state authorities that Ohio be put at once in preparation for it; and it was partly through his influence that Ohio was so very ready for the fray. * * * Two days after the proclamation of April 15, 1861, he joined the governor's staff as assistant quartermaster general. He served in the field in West Virginia with the three months men as state military engineer; with the Ohio troops under generals McClellan, Cox and Hill. * * * At the expiration of the three months service he was appointed colonel of the twentieth regiment Ohio volunteers; and was detailed by general Mitchell as chief engineer of the department of the Ohio. He planned and constructed the defences of Cincinnati."

In December, 1861, he was ordered to Kentucky with four companies of infantry "to suppress the rebel element" in several counties, with headquarters at Warsaw.[5]

Colonel Whittlesey was in command of his regiment at the taking of Fort Donelson, and was sent north with the prisoners, of whom over ten thousand five hundred were committed to him. In April, 1862, on the second day of the battle of Shiloh, colonel Whittlesey commanded the third brigade of general Wallace's division—the twentieth, forty-sixth, and seventy-eighth Ohio regiments. Under the impression that this decisive battle was the harbinger of the close of the war, he yielded to the requirements of long suffering health, and sent in his resignation.

Colonel Whittlesey soon turned his attention again to explorations in the upper Mississippi and lake Superior basins. He examined the prairies between the head of St. Louis river and Rainy lake, between the Big Fork of Rainy Lake river and the Mississippi, and between the waters of Cass lake and those of Red lake. The uniformity of level was found so

[5] In the *Magazine of Western History* for April, 1885, he gives an interesting account of his experiences there.

great as to demonstrate the practicability of canals across the various separating ridges; and colonel Whittlesey's determinations have been relied upon by the advocates of an extensive system of inland navigation in the region of the sources of the Mississippi.

After so diversified a career, it yet remained for colonel Whittlesey to enter upon an undertaking destined to insure most completely the grateful remembrance of his fellow citizens of Cleveland and northern Ohio. In 1867 he devoted his great energy and large experience to the building up of the "Western Reserve and Northern Ohio Historical Society." In this service he labored indefatigably during the remainder of his life. "All looked to him to lead the movement, and none other could have approached his efficiency or ability as president of the Society." He commenced immediately the preparation of his valuable work on "The Early History of Cleveland." He never ceased to gather important material for the archives of the Society, and contributed its most important publications. His most valuable work, however, was least conspicuous. It consisted in the constant and indefatigable zeal with which from 1867 to 1886, he promoted its prosperity. For twenty years the welfare of the Society was at all times his business and was never off his mind.

Infirmities crowded upon him—many of them the ulterior results of hardships and exposures in his northern work—but he did not as yet regard his labors as finished. During the last few years of his life, his thoughts ranged to an unusual extent, over religious themes, and the relations between science and religion. The themes were not new to him, but he now arranged his views in more systematic shape, and supplied numerous contributions for the press. Now, at length, he pronounced his life work completed. He had but a few weeks to wait. On Sunday morning, October 17, 1886, he was seized with a [illegible] and on the following day he passed from life.

The career of colonel Whittlesey, as appears from this survey, was shaped [illegible] by the circumstances which arose [illegible] period of his life he deliberately [illegible] was suggested by the [illegible] were of a different [illegible] In this way [illegible] and demands.

but sacrificed the advantages of persistent and concentrated effort in a life-long occupation. But if his labors, by lack of continuity, failed to reach the deepest principles of science, industry and human life, he gained by versatility and aptness to respond to the demands which from time to time seemed most urgent and best suited to his abilities. Thus viewing his long and useful life in retrospect, we have to contemplate him as a soldier, a geologist, an archæologist, a journalist and a religious thinker. In each of these characters he rendered service to the world, of which we would speak in a few characteristic words.

He possessed the qualities of the true soldier. These were manifest in his manly mien, in his self poise, in his terse phrase and his iron purpose. Had he not been dowered with more than soldierly gifts, his life would have been spent in the army. But his military susceptibilities were re-awakened whenever his country needed soldierly defence. His services in the War of the Rebellion were conspicuous for bravery, for prudence, for foresight, for promptness, for a humane spirit, even for a high order of generalship. At Seary Run, on the Kanawha, July 17, 1861, he distinguished himself by intrepidity and coolness during a severe engagement, in which his horse was shot under him. In Kentucky, his military energy and marked sagacity crushed treason and established order with unexpected celerity. At Fort Donelson, his conduct elicited the special commendation of generals Wallace, Force and Grant, and of senator Sherman. What is even more, his relations with his subordinates won him many expressions of profound and tender regard. But when the call to arms was no longer heard he knew how to doff his uniform and cultivate the arts of peace.

Colonel Whittlesey was a good geologist. His studies were chiefly structural and stratigraphical; and his field work was almost always upon unfossiliferous rocks; but when in Ohio, he gave due attention to the collection of organic remains, and these he carefully referred to definite physical horizons. He appreciated their significance in geological investigation.[6]

[6] The writer investigated for colonel Whittlesey, a collection from the sandstones of northern Ohio and Pennsylvania. (Proc. Acad. Nat. Sci. Phil., July, 1865, pp. 109-133.) Colonel Whittlesey himself published a description of a coal plant supposed to be new (Amer. Jour. Sci., July, 1850, with cut). His personal attention to fossils is evinced in

His earliest geological studies were made in 1838 and 1839, in connection with the first geological survey of Ohio. His reports aggregate forty-three pages. His attention was directed to the construction of maps, the running of levels, the determination of altitudes, the measurement of the thicknesses of formations, the encroachments of rivers, the fluctuation of the great lakes, the ridges of lake Erie, the variation of the magnetic needle and the survey of ancient earth works. In his subsequent explorations colonel Whittlesey paid much attention to the Drift. He early made it the subject of serious study, and was among the first to institute systematic and widely extended investigations.[7] His method of geological investigation is well illustrated by his paper of 1851, read before the American Association. In this were depicted and described seven extended sections of Drift deposits: 1. From the Canada shore of lake Erie southward through Cleveland to the summit land near Akron. 2. From Detroit westward to the summit between

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his descriptions and figures embodied in a paper on the "Equivalency of the rocks of northeastern Ohio and the Portage, Chemung and Hamilton rocks of New York." (Proc. Amer. Assoc. Adv. Sci., Cincinnati meeting, 1851, pp. 207-221.)

[7] Some of his papers are the following: Diluvium or Drift of Ohio and the West. Illustrations. pp. 12. (Amer. Jour. Sci. March, 1848.) On the superficial deposits of the northwestern part of the United States. (Proc. Amer. Assoc. Adv. Sci., Cincinnati, 1851, pp. 54-58). Drift of the northwestern States, pp. 2. (Annals of Science, Cleveland, 1852). Drift etchings, lake Superior, Illus. (Annals of Science, March, 1854). Pre-glacial channel of Eagle river, lake Superior. (Pamphlet, Boston, 1855). Natural terraces and ridges of lake Erie, pp. 9. (Amer. Jour. Sci. 1856). On the drift cavities or potash kettles of Wisconsin, pp. 2. (Proc. A. A. A. Sci., 1857). Fresh water glacial Drift of the Northwest, 4to, Illus. and maps, one colored. (Smithsonian Contributions). On the ice movement of the glacial era in the valley of the St. Lawrence, pp. 12. (Proc. A. A. A. Sci., Burlington, 1867). Glaciation of Kelly's Island, lake Erie, pp. 7. (Proc. A. A. A. Sci., 1878). The ice era in Ohio, pp. 3, 1884. Forks of the Cuyahoga, pre-glacial, inter-glacial, and post-glacial, pp. 4. 1885).

In reference to the scientific value of his work in Minnesota, we find the following in the Final Report on that state, vol. I. p. 99: "Whittlesey's grouping of 'glacial etchings' proves the direction of the glacial movement in the northern part of the state to have been from the northeast; and he unhesitatingly ascribes all the phenomena in North America to the agency of glaciers; placing the southern limit of the movement in New Jersey, northern Pennsylvania, Ohio, Indiana, Illinois, Wisconsin and Iowa. The correctness of this early prognostication has been strikingly verified by late explorations in several of the states named. He could see no reason to suppose that any changes of level of the country have taken place since the era of the Drift."

lakes Erie and Michigan. 3. From Chicago west to the summit between lake Michigan and the Mississippi. 4. From Sheboygan, Wisconsin, to lake Winnebago. 5. From LaPointe, lake Superior, to the Apuknoyekan river. 6. From the west end of lake Superior up the valley of the St. Louis river, across the Mesabi range to the Grand Fourche of Rainy Lake river. 7. A sheet of detailed sections showing the interchangeability and contemporaneous character of the *red* and *blue* clays at Racine, Milwaukee and Sault Ste. Marie. The explanation of these sections tended to show that in all parts of the northwest, east of the Mississippi, the same order of succession in the drift deposits obtains. Colonel Whittlesey had sought everywhere for organic remains, and he presented a few, referred as usual, to their precise localities, depths and surroundings, which awakened a lively discussion. He felt himself justified in conclusion, in pronouncing "all this vast, widespread, superficial mass, extending from the interior of Ohio to the plains of the Red river of the North and the Saskatchewan, one formation, with members;" and "its difference of composition—its clays, marls, hard-pans, gravel, bowlder-masses and sand ridges—due to modifications of that force, whatever it was, which brought on the materials, and in doing so, scratched, polished and abraded the surface of the underlying indurated rocks."

His study of the geology of Ohio was not restricted to one or two features. On several occasion, he treated of the general geology of the state; but more frequently, he described more limited regions or features.[8] Many of his reports on the

[8] General Geology of Ohio, with a map. 1847. (Pamphlet). Outline sketch on the geology of Ohio, with outline map of the geological formations of Ohio, pp. 13. (Howe's Historical Collections of Ohio, 1848). Geological map of Ohio, 2x2 feet, J. H. Colton & Co., New York, 1856. The equivalency of the rocks of northeastern Ohio and the Portage, Chemung and Hamilton rocks of New York, pp. 16. (Proc. A. A. A. S., Cincinnati, 1851). The lower Limestone Group Coal Series of Eastern Ohio, pp. 8. (Proc. Inst Mining Eng. 1864). Physical Geology of northeastern Ohio, 4to. pp. 9. Plate and elegant map. (Proc. Bos. Soc. Nat. Hist., Feb. 2, 1869). Physical structure of the Ohio coal field, pp. 7, 1887. (Proc. Amer. A. A. Sci., 1875). Great Coal Seam region of Ohio, pp. 7, Illus., 1877. Iron ores of the Great Coal Seam region, plates, pp. 4, 1877. Dip of the Great Coal Seam, Ohio. pp. 4, 1878. Geology of Portage county, Ohio, 1878. General geology of the counties of Columbiana, Stark and Tuscarawas. Large, 8vo. pp. 8. (Report of Secretary of State, Ohio, 1878.) Great Coal Seam, Straitsville, Ohio. pp. 6. Map. 1881.

northern regions explored contained original matter of scientific as well as economic interest. This is especially true of his discussions of the Menominee and Penokie iron regions.[9] His researches on the copper deposits of lake Superior were important;[10] and many questions of great interest were treated by his versatile pen.[11]

For several years, prior to 1869, colonel Whittlesey urged upon the public of Ohio the necessity of a reorganization of the State geological survey. When the bill was finally passed he fondly "hoped to be the chief of the survey in his own state." He had for over thirty years labored to familiarize himself with its natural features, and was generally recognized as eminently fit to direct the work of a survey. But the appointing power deemed it wise to appoint another. Colonel Whittlesey was offered a subordinate position but declined it.

As an archæologist colonel Whittlesey was early in the field, was fortunate in the material accessible, industrious in its investigation, and fruitful in results. His name will always hold high rank among American students. The fruits of his earlier labors were generously surrendered, in 1845 and 1846, to Messrs. Squier and Davis, and were embodied with due acknowledgments, in their memoir constituting the first volume of the Smithsonian "Contributions to Knowledge." A further installment of results was published in 1850, as one of the Smithsonian "contributions," and another in 1862.[12] Nu-

[9] Ferruginous quartz from Menominee river, pp. 12. (Cleveland Acad. Nat. Sci., Dec. 11, 1856). The Penokie mineral range, Ashland county, Wis., 4to, pp. 10. (Proc. Bos. Soc. Nat. Hist., 1863). Report upon the Magnetic Iron property, Ashland county, Wis. Maps. pp. 7. The Menominee iron region, pp. 4. (Kirtland Soc. Nat. Sci., Cleveland, 1880).

[10] Copper Regions of lake Superior, 12 mo. pp. 64, 1846. Report of explorations on the south side of lake Superior, in Wisconsin, with fine map, 4to, pp. 23. (D. D. Owen's Geological Rep., Washington, 1852). The Penokee copper range. (Pamphlet, 1864.)

[11] Agricultural resources of the Upper Peninsula of Michigan. (Mich. Agric. Rep., Nov. 1854). Mineral resources of the Rocky mountains, pp. 64, colored map, small, 8vo, 1865. Origin of mountain chains, pp. 4. (Proc. A. A. A. Sci., Portland, 1873). Physical Geology of lake Superior. Illus. and map, pp. 12. (Proc. A. A. A. Sci., Detroit, 1875). On the origin of mineral veins, pp. 4. (Proc. A. A. A. Sci., Buffalo, 1876.)

[12] Ancient Earth-works in Ohio, 4to, 7 plates, pp. 20. (Smithsonian Contributions, vol. III, Art. 7). Ancient mining on the shores of lake Superior, 4to, pp. 29, colored folding map and illustrations. (Smithsonian Contributions.)

merous other archæological papers were published through periodical and other channels.[13]

We have not space for entering into further details. Colonel Whittlesey's position as an archæologist is attested by such reputable and competent judges as Robert Clarke, John D. Short, John D. Baldwin, Sir Daniel Wilson, Sir John Lubbock and the Marquis de Nadaillac.

His interest in historical subjects was followed by successful efforts toward accumulating and preserving the materials of history. He zealously promoted the purchase of the St. Clair papers by the State of Ohio, published in 1882. He was very prominent in the project which ended in the publication of the Margry papers in Paris—papers so highly appreciated by Parkman, and by the late president Garfield. As member and president of the Western Reserve Historical Society, he was instrumental in securing much material, and contributed twenty-two historical tracts to its publications, besides the archæological ones already mentioned. His historical papers relate chiefly to the Northwest. They are generally brief; but his History of Cleveland (1867) is a volume of 487 pages; and several other contributions extend to 30 or 40 pages. In 1852 a selection of seventeen of his productions, mostly historical, was republished in a 12mo volume of 397 pages, under the title of "Fugitive Essays." [14]

In his relations to religion, Judge C. C. Baldwin records of him the following estimate: "He was a profoundly religious man, never ostentatiously so; but to him religion and science were twin and inseparable companions. They were in his life and thought, and he wished to, and did, live to express in print his sense that the God of science was the God of religion; and that the Maker had not lost power over the thing made." "He rounded and finished his character as he finished his life, by joint and hearty affection and service to the two joint instruments of God's revelation, for so he regarded them." * * * "He had no patience with materialism," testified his pastor,

[13] The Hesperian, July, 1839; Annals of Science, 1852; Mem. Bos. Soc. Nat. Hist., 1867; Proc. A. A. A. Sci., 1851, 1868, 1871 (2 art.), 1875; Western Reserve Histor. Soc., 1871, 1872, 1876, 1877, 1878, 1879, 1880, 1881; Proc. State Archæol. Soc., 1876, 60 pp. with many Illus. Journal of Engineers, 1883.

[14] Hudson, Ohio, Sawyer, Ingersoll & Co.

"but, in his mature strength of mind, had harmonized the facts of science with the truths of religion.[15]

Colonel Whittlesey in his life was simple, honest, earnest, positive and patriotic. In his later years he suffered much from bodily ills; but he never remitted his intellectual labors. A stranger would never have suspected the infirmities under which he sent forth during 1885 and 1886, his rapid succession of papers on scientific and theological themes. When the present writer had congratulated him in the long preservation of sufficient vigor to endure such arduous labors, he was quite astonished when his venerable friend wrote in reply—at the suggestion of his watchful and helpful wife, as he said—a catalogue of the distressing bodily ailments from which he suffered. "Ah, sir," he said, "you would not suspect that all these productions have come from the hand of an infirm old man, prostrate and helpless in his bed and on his back.

The completion of the seven theological essays referred to brought him the assurance that his work was now complete. In a few days after he had penned his last line he breathed his last breath. The faithful partner of his long and useful life did not long survive him. Honor to the memory of both.

THE MATHEMATICAL THEORIES OF THE EARTH.*

By R. S. Woodward.

The name of this section, which, by your courtesy, it is my duty to address to-day, implies a community of interest among astronomers and mathematicians. This community of interest it is not difficult to explain. We can of course imagine a considerable body of astronomical facts quite independent of mathematics. We can also imagine a much larger body of mathematical facts quite independent of and isolated from astronomy. But we never think of astronomy in the large sense without recognizing its dependence on mathematics, and we never think of mathematics as a whole without considering its capital applications in astronomy.

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[15] In the list of colonel Whittlesey's writings are fourteen titles touching religious themes—one each in 1871, 1874, 1875, 1879, 1880, two in 1878, and seven in 1886, the last year of his life, which have been republished in a pamphlet of 39 pages, entitled, "Theism and Atheism in Science." It may be added that the full list of Colonel Whittlesey's publications embraces: Historical, 56; archæological, 23; geological, 72; biographical, 7; scientific and miscellaneous, 22; religious, 14; total, 194.

* Vice-presidential address before the Section of Mathematics and Astrnomy of the American Association for the Advancement of Science, at Toronto, O t., Aug. 28-Sept. 3.

Of all the subjects and objects of common interest to us the earth will easily rank first. The earth furnishes us with a stable foundation for instrumental work and a fixed line of reference, whereby it is possible to make out the orderly arrangement and procession of our solar system and to gain some inkling of other systems which lie within telescopic range. The earth furnishes us with a most attractive store of real problems: its shape, its size, its mass, its precession and nutation, its internal heat, its earthquakes and volcanoes, and its origin and destiny, are to be classed with the leading questions for astronomical and mathematical research. We must of course recognize the claims of our friends the geologists to that indefinable something called the earth's crust, but, considered in its entirety and in its relations to similar bodies of the universe, the earth has long been the special province of astronomers and mathematicians. Since the times of Galileo and Kepler and Copernicus it has supplied a perennial stimulus to observation and investigation, and it promises to tax the resources of the ablest observers and analysts for some centuries to come. The mere mention of the names of Newton, Bradley, d'Alembert, Laplace, Fourier, Gauss, and Bessel calls to mind not only a long list of inventions and discoveries, but the most important parts of mathematical literature. In its dynamical and physical aspects the earth was to them the principal object of research, and the thoroughness and completeness of their contributions toward an explanation of the "system of the world" are still a source of wonder and admiration to all who take the trouble to examine their works.

A detailed discussion of the known properties of the earth and of the hypotheses concerning the unknown properties, is no fit task for a summer afternoon; the intricacies and delicacies of the subject are suitable only for another season and a special audience. But it has seemed that a somewhat popular review of the state of our mathematical knowledge of the earth might not be without interest to those already familiar with the complex details, and might also help to increase that general interest in science, the promotion of which is one of the most important functions of this association.

As we look back through the light of modern analysis, it seems strange that the successors of Newton, who took up the problem of the shape of the earth, should have divided into hostile camps over the question whether our planet is elongated or flattened at the poles. They agreed in the opinion that the earth is a spheroid, but they debated, investigated, and observed for nearly half a century before deciding that the spheroid is oblate rather than oblong. This was a critical question, and its decision marks perhaps the most important epoch in the history of the figure of the earth. The Newtonian view of the oblate form found its ablest supporters in Huyghens, Maupertuis, and Clairaut, while the erroneous view was maintained with great vigor by the justly distinguished Cassinian school of astronomers. Unfortunately for the Cassinians, defective measures of a

meridional arc in France gave color to the false theory and furnished one of the most conspicuous instances of the deterring effect of an incorrect observation. As you well know, the point was definitely settled by Maupertuis's measurement of the Lapland arc. For this achievement his name has become famous in literature as well as in science, for his friend Voltaire congratulated him on having "flattened the poles and the Cassinis," and Carlisle has honored him with the title of "Earth flattener."

Since the settlement of the qnestion of the form, progress towards a knowledge of the size of the earth has been consistent and steady, until now it may be said that there are few objects with which we have to deal whose dimensions are so well known as the dimensions of the earth. But this is a popular statement, and like most such needs to be explained in order not to be misunderstood. Both the size and shape of the earth are defined by the lengths of its equatorial and polar axes; and, knowing the fact of the oblate spheroidal form, the lengths of the axis may be found within narrow limits from simple measurements conducted on the surface, quite independently of any knowledge of the interior constitution of the earth. It is evident in fact, without recourse to mathematical details, that the length of any arc, as a degree of latitude or longitude, on the earth's surface, must depend on the lengths of those axes. Conversely it is plain that the measurement of such an arc on the surface and the determination of its geographical position, constitute an indirect measurement of the axes. Hence it has happened that scientific as distinguished from practical geodesy has been concerned chiefly with such linear and astronomical measurements, and the zeal with which this work has been pursued is attested by triangulations on every continent.

Passing over the earlier determinations as of historical interest only, all of the really trustworthy approximations to the lengths of the axes have been made within the half century just passed. The first to appear of these approximations were the well-founded values of Airy, published in 1830. These, however, were almost wholly overshadowed and supplanted eleven years later by the values of Bessel, whose spheroid came to occupy a most conspicuous place in geodesy for more than a quarter of a century. Knowing as we now do that Bessel's values were considerably in error, it seems not a little remarkable that they should have been so long accepted without serious question. One obvious reason is found in the fact that a considerable lapse of time was essential for the accumulation of new data, but two other possible reasons of a different character are worthy of notice, because they are interesting and instructive whether specially applied to this particular case or not. It seems not improbable that the close agreement of the values of Airy and Bessel, computed independently and by different methods, —the greatest discrepency being about one hundred and fifty feet,— may have been incautiously interpreted as a confirmation of Bessel's

dimensions, and hence led to their too ready adoption. It seems also not improbable that the weight of Bessel's great name may have been too closely associated in the minds of his followers with the weight of his observations and results. The sanction of eminent authority, especially if there is added to it the stamp of an official seal, is sometimes a serious obstacle to real progress. We can not do less than accord to Bessel the first place among the astronomers and geodesists of his day, but this is no adequate justification for the exaggerated estimate long entertained of the precision of the elements of his spheroid.

The next step in the approximation was the important one of Clarke in 1866. His new values showed an increase over Bessel's of about half a mile in the equatorial semi-axis and about three-tenths of a mile in the polar semi-axis. Since 1866 general Clarke has kept pace with the accumulating data, and given us so many different elements for our spheroid that it is necessary to affix a date to any of his values we may use. The later values, however, differ but slightly from the earlier ones, so that the spheroid of 1866, which has come to be pretty generally adopted, seems likely to enjoy a justly greater celebrity than that of its immediate predecessor. The probable error of the axes of this spheroid is not much greater than the hundred thousandth part, and it is not likely that new data will change their lengths by more than a few hundred feet.

In the present state of science, therefore, it may be said that the first order of approximation to the form and dimensions of the earth has been successfully attained. The question which follows naturally and immediately is, how much further can the approximation be carried? The answer to this question is not written, and the indications are not favorable for its speedy announcement. The first approximation, as we have seen, requires no knowledge of the interior density and arrangement of the earth's mass; it proceeds on the simple assumption that the sea surface is closely spheroidal. The second approximation, if it be more than a mere interpolation formula, requires a knowledge of both the density and arrangement of the constituents of the earth's mass, and especially of that part called the crust. "All astronomy," says Laplace, "rests on the stability of the earth's axis of rotation." In a similar sense we may say all geodesy rests on the direction of the plumb-line. The simple hypothesis of a spheroidal form assumes that the plumb-line is everywhere coincident with the normal to the spheroid, or that the surface of the spheroid coincides with the level of the sea. But this is not quite correct. The plumb-line is not in general coincident with the normal, and the actual sea level or geoid must be imagined to be an irregular surface lying partly above and partly below the ideal spheroidal surface. The deviations, it is true, are relatively small, but they are in general much greater than the unavoidable errors of observation, and they are the exact numerical expression of our ignorance in this branch of geodesy. It is well known, of course, that deflections of the plumb-

line can sometimes be accounted for by visible masses, but on the whole it must be admitted that we possess only the vaguest notions of their cause and a most inadequate knowledge of their distribution and extent.

What is true of plum-line deflections is about equally true of the deviations of the intensity of gravity from what may be called the spheroidal type. Given a closely spheroidal form of the sea level and it follows from the law of gravitation, as a first approximation, without any knowledge of the distribution of the earth's mass, that the increase of gravity varies as the square of the sine of the latitude in passing from the equator to the poles. This is the remarkable theorem of Stokes, and it enables us to determine the form of ellipticity of the earth, by means of pendulum observations alone. It must be admitted, however, that the values for the ellipticity recently obtained in this way by the highest authorities, Clarke and Helmert, are far from satisfactory, whether we regard them in the light of their discrepency or in the light of the different methods of computing them. In general terms we may say that the difficulty in the way of the use of pendulum observations still hinges on the treatment of local anomalies and on the question of reduction to sea level. At present the case is one concerning which the doctors agree neither in their diagnosis nor in their remedies.

Turning attention now from the surface, towards the interior, what can be said of the earth's mass as a whole, of its laws of distribution, and of the pressures that exist at great depths? Two facts, namely, the mean density and the surface density, are roughly known; and a third fact, namely, the precession constant, or the ratio of the difference of the two principal moments of inertia to the greater of them, is known with something like precision. These facts lie within the domain of observation, and require only the law of gravitation for their verification. Certain inferences also from these facts and others have long been and still are held to be hardly less cogent and trustworthy, but before stating them, it will be well to recall briefly the progress of opinion concerning this general subject during the past century and a half.

The conception of the earth as having been primitively fluid was the prevailing one among mathematicians before Clairaut published his "Théorie de la Figure de la Terre" in 1743. By the aid of this conception Clairaut proved the celebrated theorem which bears his name, and probably no idea in the mechanics of the earth has been more suggestive and fruitful. It was the central idea in the elaborate investigations of Laplace, and received at his hands a development which his successors have found it about equally difficult to displace or to improve. From the idea of fluidity spring naturally the hydrostatical notions of pressure and level surfaces, or the arrangement of fluid masses in strata of uniform density. Hence follows, also, the notion of continuity of increase in density from the surface towards the center

of the earth. All of the principal mechanical properties and effects of the earth's mass, viz., the ellipticity, the surface density, the mean density, the precession constant, and the lunar inequalities were correlated by Laplace in a single hypothesis, involving only one assumption in addition to that of original fluidity and the law of gravitation. This assumption relates to the compressibility of matter, and asserts that the ratio of the increment of pressure to the increment of density s proportional to the density. Many interesting and striking conclusions follow readily from this hypothesis, but the most interesting and important are those relative to density and pressure, especially the latter, whose dominance as a factor in the mechanics of celestial masses seems destined to survive whether the hypothesis stands or falls. The hypothesis requires that while the density increases slowly from something less than 3 at the surface to about 11 at the center of the earth, the pressure within the mass increases rapidly below the surface, reaching a value surpassing the crushing strength of steel at the depth of a few miles, and amounting at the center to no less than three million atmospheres. The inferences, then, as distinguished from the facts, are that the mass of the earth is very nearly symmetrically disposed about its centre of gravity, that pressure and density except near the surface are mutually dependent, and that the earth in reaching this stage has passed through the fluid or quasi-fluid state.

Later writers have suggested other hypotheses for a continuous distribution of the earth's mass, but none of them can be said to rival the hypothesis of Laplace. Their defects lie either in not postulating a direct connection between density and pressure or in postulating a connection which implies extreme or impossible values for these and other mechanical properties of the mass.

It is clear from the positiveness of his language in frequent allusions to this conception of the earth, that Laplace was deeply impressed with its essential correctness. "Observations," he says, "prove incontestably that the densities of the strata [*couches*] of the terrestrial spheroid increase from the surface to the center;" and "the regularity with which the observed variation in lengths of a seconds pendulum follows the law of the squares of the sines of the latitudes, proves that the strata are arranged symmetrically about the center of gravity of the earth." The more recent investigations of Stokes, to which allusion has already been made, forbid our entertaining anything like so confident an opinion of the earth's primitive fluidity or of a symmetrical and continuous arrangement of its strata. But, though it must be said that the sufficiency of Laplace's arguments has been seriously impugned, we can hardly think the probability of the correctness of his conclusions has been proportionately diminished.

Suppose, however, that we reject the idea of original fluidity. Would not a rotating mass of the size of the earth assume finally the same aspects and properties presented by our planet? Would not pressure and centrifugal force suffice to bring about a central condensa-

tion and a symmetrical arrangement of strata similar at least to that required by the Laplacian hypothesis? Categorical answers to these questions can not be given. But whatever may have been the antecedent condition of the earth's mass, the conclusion seems unavoidable that at no great depth the pressure is sufficient to break down the structional characteristics of all known substances, and hence to produce viscous flow whenever and wherever the stress difference exceeds a certain limit, which can not be large in comparison with the pressure. Purely observational evidence also of a highly affirmative kind in support of this conclusion, is afforded by the remarkable results of Tresca's experiments on the flow of solids and by the abundant proofs in geology of the plastic movements and viscous flow of rocks. With such views and facts in mind, the fluid stage considered indispensable by Laplace, does not appear necessary to the evolution of a planet, even if it reach the extreme refinement of a close fulfilment of some such mathematical law as that of his hypotheses. If, as is here assumed, pressure be the dominant factor in such large masses, the attainment of a stable distribution would be simply a question of time. The fluid mass might take on its normal form in a few days or a few months, whereas the viscous mass might require a few thousand or a few million years.

Some physicists and mathematicians, on the other hand, reject both the idea of the existence of great pressures within the earth's mass, and the notion of an approach to continuity in the distribution of density. As representing this side of the question, the views of the late M. Roche, who wrote much on the constitution of the earth, are worthy of consideration. He tells us that the very magnitude of the central pressure computed an the hypothesis of fluidity is itself a peremptory objection to that hypothesis. According to his conception, the strata of the earth from the center outwards are substantially self-supporting and unyielding. It does not appear, however, that he had submitted this conception to the test of numbers, for a simple calculation will show that no materials of which we have any knowledge would sustain the stress in such shells or domes. If the crust of the earth were self-supporting, its crushing strength would have to be about thirty times that of the best cast steel or five to one thousand times that of granite. The views of Roche on the distribution of terrestrial densities appear equally extreme. He prefers to consider the mass as made up of two distinct parts, an outer shell or crust whose thickness is about one-sixth of the earth's radius, and a solid nucleus having little or no central condensation. The nucleus is conceived to be purely metallic, and to have about the same density as iron. To account for geological phenomena, he postulates a zone of fusion separating the crust from the nucleus. The whole hypothesis is consistently worked out in conformity with the requirements of ellipticity, the superficial density, the mean density, and precession; so that to one who can divest his mind of the notion that pressure and continuity are

important factors in the mechanics of such masses, the picture which Roche draws of the constitution of our planet will present nothing incongruous.

In a field so little explored and so inaccessible, though hedged about as we have seen by certain sharply limiting conditions, there is room for a wide range of opinion and for great freedom in the play of hypothesis; and though the preponderance of evidence appears to be in favor of a terrestrial mass in which the reign of pressure is well-nigh absolute, we should not be surprised a few decades or centuries hence to find many of our notions on this subject radically defective.

If the problem of the constitution and distribution of the earth's mass is yet an obscure and difficult one after two centuries of observation and investigation, can we report any greater degree of success in the treatment of that still older problem of the earth's internal heat, of its origin and effects? Concerning phenomena always so impressive and often so terribly destructive as those intimately connected with the terrestrial store of heat, it is natural that there should be a considerable variety of opinion. The consensus of such opinion, however, has long been in favor of the hypothesis that heat is the active cause of many and a potent factor in most of the grander phenomena which geologists assign to the earth's crust; and the prevailing interpretation of these phenomena is based on the assumption that our planet is a cooling sphere whose outer shell or crust is constantly cracked and crumpled in adjusting itself to the shrinking nucleus.

The conception that the earth was originally an intensely heated and molten mass appears to have first taken something like definite form in the minds of Leibnitz and Descartes. But neither of these philosophers was armed with the necessary mathematical equipment to subject this conception to the test of numerical calculation. Indeed it was not fashionable in their day, any more than it is with some philosophers in ours, to undertake the drudgery of applying the machinery of analysis to the details of an hypothesis. Nearly a century elapsed before an order of intellects capable of dealing with this class of questions appeared. It was reserved for Joseph Fourier to lay the foundation and build a great part of the superstructure of our modern theory of heat diffusion, his avowed desire being to solve the great problem of terrestrial heat. "The question of terrestrial temperatures," he says, "has always appeared to us one of the grandest objects of cosmological studies, and we have had it constantly in view in establishing the mathematical theory of heat." This ambition, however, was only partly realized. Probably Fourier underestimated the difficulties of his problem, for his most ingenious and industrious successors in the same field have made little progress beyond the limits he attained. But the work he left is a perennial index to his genius. Though quite inadequately appreciated by his contemporaries, the "Analytical Theory of Heat," which appeared in 182[illegible], is now conceded to be one of the epoch-making books. Indeed, to one who has caught the spirit

of the extraordinary analysis which Fourier developed and illustrated by numerous applications in this treatise, it is evident that he opened a field whose resources are still far from being exhausted. A little later Poisson took up the same class of questions and published another great work on the mathematical theory of heat. Poisson narrowly missed being the foremost mathematician of his day. In originality, in wealth of mathematical resources, and in breadth of grasp of physical principles, he was the peer of the ablest of his contemporaries. In lucidity of exposition it would be enough to say that he was a Frenchman, but he seems to have excelled in this peculiarly national trait. His contributions to the theory of heat have been somewhat overshadowed in recent times by the earlier and perhaps more brilliant researches of Fourier, but no student can afford to take up that enticing though difficult theory without the aid of Poisson as well as Fourier.

It is natural, therefore, that we should inquire what opinions these great masters in the mathematics of heat diffusion held concerning the earth's store of heat. I say "opinions," for, unhappily, the whole subject is still so largely a matter of opinion that in discussing it one may not inappropriately adopt the famous caution of Marcus Aurelius,—"Remember that all is opinion." It does not appear that Fourier reached any definite conclusion on this question, though he seems to have favored this view that the earth in cooling from an earlier state of incandescence reached finally, through convection, a condition in which there was a uniform distribution of heat throughout its mass. This is the *consistentoir status* of Leibnitz, and it begins with the formation of the earth's crust if not with the consolidation of the entire mass. It thus affords an initial distribution of heat and an epoch from which analysis may start, and the problem for the mathematician is to assign the subsequent distribution of heat and the resulting mechanical effects. But no great amount of reflection is necessary to convince one that the analysis can not proceed without making a few more assumptions. The assumptions which involve the least difficulty, and which for this reason partly have met with most favor, are that the conductivity and thermal capacity of the entire mass remain constant, and that the heat conducted to the surface of the earth passes off by the combined process of radiation, convection, and conduction, without producing any sensible effect on surrounding space. These or similar assumptions must be made before the application of theory can begin. In addition, two data are essential to numerical calculations, namely, the diffusivity, or the ratio of the conductivity of the mass to its thermal capacity, and the initial uniform temperature. The first of these can be observed approximately at least; the second can only be estimated at present. With respect to these important points which must be considered after the adoption of the *consistentoir status*, the writings of Fourier afford little light. He was content, perhaps, to invent and develop the exquisite analysis requisite to the treatment of such problems.

Poisson wrote much on the whole subject of terrestrial temperatures, and carefully considered most of the troublesome details which lay between his theory and its application. While he admitted the nebular hypothesis and an initial fluid state of the earth, he rejected the notion that the observed increase of underground temperature is due to a primitive store of heat. If the earth was originally fluid by reason of its heat, a supposition which Poisson regarded quite gratuitous, he conceived that it must cool and consolidate from the center outwards; so that according to this view the crust of our planet arrived at a condition of stability only after the supply of heat had been exhausted. But Poisson was not at a loss to account for the observed temperature gradient in the earth's crust. Always fertile in hypothesis, he advanced the idea that there exist, by reason of interstellar radiations, great variations in the temperature of space, some vast regions being comparatively cool and others intensely hot, and the present store of terrestrial heat was acquired by a journey of the solar system through one of the hotter regions. "Such is," he says, "in my opinion, the true cause of the augmentation of temperature which occurs as we descend below the surface of the globe." This hypothesis was the result of Poisson's mature reflection, and as such is well worthy of attention. The notion that there exist hot foci in space was advanced also in another form in 1852 by Rankine, in his interesting speculation on the reconcentration of energy. But whatever we may think of the hypothesis as a whole, it does not appear to be adequate to the case of the earth unless we suppose the epoch of transit through the hot region exceedingly remote and the temperature of that region exceedingly high. The continuity of geological and palæontological phenomena is much better satisfied by the Leibnitzian view of an earth long subject to comparatively constant surface conditions but still active with the energy of its primitive heat.

Notwithstanding the indefatigable and admirable labors of Fourier and Poisson in this field, it must be admitted that they accomplished little more than the preparation of the machinery with which their successors have sought and are still seeking to reap the harvest. The difficulties which lay in their way were not mathematical but physical. Had they been able to make out the true conditions of the earth's store of heat, they would undoubtedly have reached a high grade of perfection in the treatment of the problem. The theory as they left it was much in advance of observation, and the labors of their successors have therefore necessarily been directed largely towards the determination of the thermal properties of the earth's crust and mass.

Of those who in the present generation have contributed to our knowledge and stimulated the investigation of this subject, it is hardly necessary to say that we owe most to Sir William Thomson. He has made the question of terrestrial temperatures highly attractive and instructive to astronomers and mathematicians, and not less warmly

interesting to geologists and palæontologists. Whether we are prepared to accept his conclusions or not, we must all acknowledge our indebtedness to the contributions of his master hand in this field as well as in most other fields of terrestrial physics. The contribution of special interest to us in this connection is his remarkable memoir on the secular cooling of the earth. In this memoir he adopts the simple hypothesis of a solid sphere whose thermal properties remain invariable while it cools by conduction from an initial state of uniform temperature, and draws therefrom certain striking limitations on geologic time. Many geologists were startled by these limitations, and geologic thought and opinion have since been widely influenced by them. It will be of interest, therefore, to state a little more fully and clearly the grounds from which his arguments proceed. Conceive a sphere having a uniform temperature initially, to cool in a medium which instantly dissipates all heat brought by conduction to its surface, thus keeping the surface at a constant temperature. Suppose we have given the initial excess of the sphere's temperature over that of the medium. Suppose also that the capacity of the mass of the sphere for diffusion of heat is known, and known to remain invariable during the process of cooling. This capacity is called diffusivity, and is a constant which can be observed. Then from these data the distribution of temperature at any future time can be assigned, and hence also the rate of temperature increase, or the temperature gradient, from the surface towards the center of the sphere can be computed. It is tolerably certain that the heat conducted from the interior to the surface of the earth does not set up any reaction which in any sensible degree retards the process of cooling. It escapes so freely that, for practical purposes we may say it is instantly dissipated. Hence if we can assume that the earth had a specified uniform temperature at the initial epoch, and can assume its diffusivity to remain constant, the whole history of cooling is known as soon as we determine the diffusivity and the temperature gradient at any point. Now Sir William Thomson determined a value for the diffusivity from measurements of the seasonal variations of underground temperatures, and numerous observations of the increase of temperature with depth below the earth's surface gave an average value for the temperature gradient. From these elements and from an assumed initial temperature of 7,000°, he infers that geologic time is limited to something between twenty million and four hundred million years. He says: "We must allow very wide limits in such an estimate as I have attempted to make; but I think we may with much probability say that the consolidation can not have taken place less than twenty million years ago, or we should have more underground heat than we actually have, nor more than four hundred million years ago, or we should not have so much as the least observed underground increment of temperature. That is to say, I conclude that Leibnitz's epoch of emergence of the *consistentior status* was probably between those dates." These conclu-

sions were announced twenty-seven years ago, and were republished without modification in 1883.

Recently, also, professor Tait, reasoning from the same basis, has insisted with equal confidence on cutting down the upper limit of geologic time to some such figures as ten million or fifteen million years. As mathematicians and astronomers, we must all confess to a deep interest in these conclusions and the hypothesis from which they flow. They are very important if true. But what are the probabilities? Having been at some pains to look into this matter, I feel bound to state that, although the hypothesis appears to be the best which can be formulated at present, the odds are against its correctness. Its weak links are the unverified assumptions of an initial uniform temperature and a constant diffusivity. Very likely these are approximations, but of what order we can not decide. Furthermore, if we accept the hypothesis the odds appear to be against the present attainment of trustworthy numerical results, since the data for calculation obtained mostly from observations on continental areas are far too meagre to give satisfactory average values for the entire mass of the earth. In short, this phase of the case seems to stand about where it did twenty years ago, when Huxley warned us that the perfection of our mathematical mill is no guaranty of the quality of the grist, adding that, "as the grandest mill will not extract wheat-flour from peas-cods, so pages of formulæ will not get a definite result out of loose data."

When we pass from the restricted domain of quantitative results concerning geologic time to the freer domain of qualitative results of a general character, the contractional theory of the earth may be said to still lead all others, though it seems destined to require more or less modification, if not to be relegated to a place of secondary importance. Old as is the notion that the great surface irregularities of the earth are but the outward evidence of a crumpling crust, it is only recently that this notion has been subjected to mathematical analysis on anything like a rational basis. About three years ago Mr. T. Mellard Reade announced the doctrine that the earth's crust, from the joint effect of its heat and gravitation, should behave in a way somewhat analagous to a bent beam, and should possess at a certain depth a "level of no strain," corresponding to the neutral surface in a beam. Above the level of no strain, according to this doctrine, the strata will be subjected to compression, and will undergo crumpling, while below that level the tendency of the strata to crack and part is overcome by pressure which produces what Reade calls "compressive extension," thus keeping the nucleus compact and continuous. A little later the same idea was worked out independently by Mr. Charles Davison, and it has since received elaborate mathematical treatment at the hands of Darwin, Fisher, and others. The doctrine requires for its application a competent theory of cooling, and hence can not be depended on at present to give anything better than a general idea of

the mechanics of crumpling and a rough estimate of the magnitudes of the resulting effects. Using Thomson's hypothesis, it appears that the stratum of no strain moves downward from the surface of the earth at a nearly constant rate during the earlier stages of cooling, but more slowly during later stages. Its depth is independent of the initial temperature of the earth; and if we adopt Thompson's value of the diffusivity, it will be about two and a third miles below the surface in a hundred million years from the beginning of cooling and a little more than fourteen miles below the surface in seven hundred million years. The most important inference from this theory is that the geological effects of secular cooling will be confined for a very long time to a comparatively thin crust. Thus, if the earth is a hundred million years old, crumpling should not extend much deeper than two miles. A test to which the theory has been subjected, and one which some consider crucial against it, is the volumetric amount of crumpling shown by the earth at the present time. This is a difficult quantity to estimate, but it appears to be much greater than the theory alone can account for.

The opponents of the contractional theory of the earth, believing it quantitatively insufficient, have recently revived and elaborated an idea first suggested by Babbage and Herschel in explanation of the greater folds and movements of the crust. This idea figures the crust as being in a state bordering on hydrostatic equilibrium, which cannot be greatly disturbed without a readjustment and consequent movement of the masses involved. According to this view, the transfer of any considerable load from one area to another is followed sooner or later by a depression over the loaded area and a corresponding elevation over the unloaded one; and in a general way it is inferred that the elevation of continental areas tends to keep pace with erosion. The process by which this balance is maintained has been called "isostacy," and the crust is said to be in an isostatic state. The dynamics of the superficial strata with the attendant phenomena of folding and faulting, are thus referred to gravitation alone, or to gravitation and whatever opposing force the rigidity of the strata may offer. In a mathematical sense, however, the theory of isostacy is in a less satisfactory state than the theory of contraction. As yet we can see only that isostacy is an efficient cause if once set in action; but how it is started and to what extent it is adequate remains to be determined. Moreover isostacy alone does not seem to meet the requirements of geological continuity, for it tends rapidly towards stable equilibrium, and the crust ought therefore to reach a state of repose early in geologic time. But there is no evidence that such a state has been attained, and but little if any evidence of diminished activity in crustal movement during recent geologic time. Hence we infer that isostacy is competent only on the supposition that it is kept in action by some other cause tending constantly to disturb the equilibrium which would otherwise result. Such a cause is found in secular contraction, and it

is not improbable that these two seemingly divergent theories are really supplementary.

Closely related to the questions of secular contraction and the mechanics of crust movements are those vexed questions of earthquakes, volcanism, the liquidity or solidity of the interior, and the rigidity of the earth's mass as a whole,—all questions of the greatest interest but still lingering on the battlefields of scientific opinion. Many of the "thrice slain" combatants in these contests would fain risk being slain again; and whether our foundation be liquid or solid, or to speak more precisely, whether the earth may not be at once highly plastic under the action of long continued forces and highly rigid under the action of periodic forces of short period, it is pretty certain that some years must elapse before the arguments will be convincing to all concerned. The difficulties appear to be due principally to our profound ignorance of the properties of matter subject to the joint action of great pressure and great heat. The conditions which exist a few miles beneath the surface of the earth are quite beyond the reach of laboratory tests as hitherto developed, but it is not clear how our knowledge is to be improved without resort to experiments of a scale in some degree comparable with the facts to be explained. In the mean time, therefore, we may expect to go on theorizing, adding to the long list of dead theories which mark the progress of scientific thought, with the hope of attaining the truth not so much by direct discovery as by the laborious process of eliminating error.

When we take a more comprehensive view of the problems presented by the earth, and look for light on their solution in theories of cosmogony, the difficulties which beset us are no less numerous and formidable than those encountered along special lines of attack. Much progress has recently been made, however, in the elaboration of such theories. Roche, Darwin, and others have done much to remove the nebulosity of Laplace's nebular hypothesis. Poincaré and Darwin have gone far towards bridging the gaps which have long rendered the theory of rotating fluid masses incomplete. Poincaré has in fact shown us how a homogeneous rotating mass might, through loss of heat and consequent contraction, pass from the spheroidal form to the Jacobian ellipsoidal form, and thence, by reason of its increasing speed of rotation, separate into two unequal masses. Darwin, starting with a swarm of meteorites and gravitation as a basis, has reached many interesting and instructive results in the endeavor to trace out the laws of evolution of a planetary system. But notwithstanding the splendid researches of these and other investigators in this field, it must be said that the real case of the solar system, of the earth and moon, still defies analysis; and that the mechanics of the segregation of a planet from the sun or of a satellite from a planet, if such an event has ever happened, or of the mechanics of the evolution of a solar system from a swarm of meteorites, are still far from being clearly made out.

Time does not permit me to make anything but the briefest allusion to the comparatively new science of mathematical meteorology, with its already considerable list of well-defined theories pressing for acceptance or rejection. Nor need I say more with reference to those older mathematical questions of the tides and terrestrial magnetism than that they are still unsettled. These and many other questions, old and new, might serve equally well to illustrate the principal fact this address has been designed to emphasize, namely, that the mathematical theories of the earth already advanced and elaborated are by no means complete, and that no mathematical Alexander need yet pine for other worlds to conquer.

Speculations concerning the course and progress of science are usually untrustworthy if not altogether fallacious. But, being delegated for the hour to speak to and for mathematicians and astronomers, it may be permissible to offer, in closing, a single suggestion, which will perhaps help us to orient ourselves aright in our various fields of research. If the curve of scientific progress in any domain of thought could be drawn, there is every reason to believe that it would exhibit considerable irregularities. There would be marked maxima and minima in its general tendency towards the limit of perfect knowledge; and it seems not improbable that the curve would show throughout some portions of its length a more or less definitely periodic succession of maxima and minima. Races and communities as well as individuals, the armies in pursuit of truth as well as those in pursuit of plunder, have their periods of culminating activity and their periods of placid repose. It is a curious fact that the history of the mathematical theories of the earth presents some such periodicity. We have the marked maximum of the epoch of Newton near the end of the seventeenth century, with the equally marked maximum of the epoch of Laplace near the end of the eighteenth centuty; and judging from the recent revival of geodesy and astronomy in Europe, and from the well-nigh general activity in mathematical and geological research, we may hope if not expect that the end of the present century will signalize a similar epoch of productive activity. The minima periods which followed the of epochs Newton and Laplace are less definitely marked but not less noteworthy and instructive. They were not periods of placid repose; to find such one must go back into the night of the middle ages; but they were periods of greatly dimished energy, periods during which those who kept alive the spirit of investigation were almost as conspicuous for their isolation as for their distinguished abilities. Many causes, of course, contributed to produce these minima periods, and it would be an interesting study in philosophic history to trace out the tendency and effect of each cause. It is desired here, however, to call attention to only one cause which contributed to the somewhat general apathy of the periods mentioned, and which always threatens to dampen the ardor of research immediately after the attainment of any marked success or advance. I refer

to the impression of contentment with and acquiescence in the results of science, which seems to find easy access to trained as well as untrained minds before an investigation is half completed or even fairly begun. That some such tacit persuasion of the completeness of the knowledge of the earth has at times pervaded scientific thought, there can be no doubt. This was notably the case during the period which followed the remarkable epoch of Laplace. The profound impression of the sufficiency of the brilliant discoveries and advances of that epoch is aptly described by Carlyle, in the half humorous, half sarcastic language of Sartor Resartus. "Our Theory of Gravitation," he says, "is as good as perfect: Lagrange, it is well known, has proved that the Planetary System, on this scheme, will endure forever; Laplace, still more cunningly, even guesses that it could not have been made on any other scheme. Whereby, at least, our nautical Logbooks can be better kept; and water transport of all kinds has grown more commodious. Of Geology and Geognosy we know enough; what with the labors of our Werners and Huttons, what with the ardent genius of their disciples, it has come about that now, to many a Royal Society, the creation of a World is little more mysterious than the cooking of a dumpling; concerning which last, indeed, there have been minds to whom the question, *How the apples were got in*, presented difficulties." This was written nearly sixty years ago, about the time that the sage of Ecclefechan abandoned his mathematics and astronomy for literature to become the seer of Chelsea, but the force of its irony is still applicable for we have yet to learn essentially, "how the apples were got in," and what kind they are.

As to the future, we can only guess, less or more vaguely, from our experience in the past and from our knowledge of present needs. Though the dawn of that future is certainly not heralded by rosy tints of over confidence amongst those acquainted with the difficulties to be overcome, the prospect, on the whole, has never been more promising. The converging lights of many lines of investigation are now brought to bear on the problems presented by our planet. There is ample reason to suppose that our day will witness a fair average of those happy accidents in science which lead to the discovery of new principles and new methods. We have much to expect from the elaborate machinery and perfected methods of the older and more exact sciences of measuring and weighing—astronomy, geodesy, physics and chemistry. We have more to expect, perhaps, from geology and meteorology, with their vast accumulation of facts not yet fully correlated. Much, also may be anticipated from that new astronomy which looks for the secrets of the earth's origin and history in nebulous masses or in swarms of meteorites. We have the encouraging stimulus of very general and rapidly growing popular concern in the objects of our inquiries, and the freest avenues for the dissemination of new information; so that we may easily gain the advantagc of a concentration of energy without centralization of personal interests. To those, there-

fore, who can bring the prerequisites of endless patience and unflagging industry, who can bear alike the remorseless discipline of repeated failure and the prosperity of partial success, the field is as wide and as inviting as it ever was to a Newton or Laplace.

GEOLOGY IN THE HIGH SCHOOL.

BY VICTOR CLIFTON ALDERSON.

To arrange the work in a single study in a high school so that it shall satisfy the demands of the college professor, who looks upon the high school as a fitting school for college, and the great mass of the community that thinks the girls must be prepared for teaching or clerkships, the boys for business, and a small minority for college, is no easy task. The following outline of work, freed from the limits of any single text book, and having as its field the subject of geology in its broadest sense, will serve to show the attempted solution of the problem as it is in operation in the Englewood (Chicago) high school, and may serve in some measure as a suggestion to other workers in other places. It may also show the specialist how the simplest facts, so patent to him, may be adapted to the needs of the young.

The first main object is to understand the home geology in whatever form that may be presented. With us, as long as the weather remains fine in the fall and after the frost is out of the ground in the spring, one or more excursions are made each week in the field. The first excursion is generally to the shore of lake Michigan. Hitherto the pupils' minds have been closed to a full realization of the forces of nature in operation. That sand is made by the wearing away of pebbles, that pebbles have a life history, that sand dunes are made by the sand blown up from the beach, are wonderful revelations to them. These facts they can see, realize, and believe, and come home thinking that geology is the grandest study they ever pursued. Their enthusiasm might seem remarkable but the solution is clear. The field of their other studies has been the class room; now they study the world and their class room becomes nature itself. On other excursions, they observe in the excavations for cellars and at the road cuttings into the surrounding ridges, the stratified sand and gravel. These facts lead them to understand the proofs for the higher level of lake Michigan in past times. At Stony Island, ten miles south of Chicago, they find an anticlinal,

glaciated pepples, bowlder clay and glacial striæ on the Niagara bed-rock. These facts, together with the observations on the many bowlders scattered over this region leads them on instinctively to the glacial theory as an explanation. The Niagara outcrops at south Chicago, eleven miles south of the city, at Bridgeport within the old city limits, at Hawthorne five miles west on the Chicago, Burlington & Quincy R.R., at Thornton twenty miles south on the Chicago & Eastern Illinois R.R., and at Joliet, all of which places they visit, collect materials for their work and gather the nucleus of many private cabinets. From the bowlders they gather an almost endless supply of specimens for the study of mineralogy and lithology. At south Chicago they gather *Favosites niagarensis*, *Caryocrinus ornatus*, *Orthoceras scammoni*, *Orthoceras annulatum* and beautiful samples of pyrites. At Bridgeport, the most fruitful field, they get *Eucalyptocrinus chicagoensis*, *E. ornatus*, *E. cornutus* var. *excavatus*, *Icthyocrinus corbis*, *Amphicœlia neglecta*, *Strophomena rhomboidalis*, *Glyptocrinus ornatus*, and many other species. At Thornton they find Stromatopora concentrica, excellent specimens of geodes, and bitumen in abundance. At Joliet they find many specimens of *Calymene niagerensis*. They frequently find rare specimens, as *Calymene niagarensis* at Stoney island—the first I have known to be found there. In fact hardly an excursion is made that does not develop some new fact about our home geology and their appetite becomes whetted for more discoveries. But the commoner forms, such as I have mentioned, are the only ones that are made the basis of class room work and all are expected to find at least one specimen of each.

Before each trip is made a list of questions and suggestions is given the class in order to enable them to observe the geological features to be met. After the return as much time is taken as is needed for a retrospective view, discussion, and explanation of what has been seen. For example: one excursion is to a part of the ridge, or terrace known as Forest Hills. Where the road cuts into the terrace, stratified sand is found at the very top. The United States Geodetic Survey gives the altitude of Morgan park—which is at about the same level —at 84 feet above lake Michigan. Discussion then brings to light the facts relative to the former high level of the lake, the

discharge of its waters through the Desplaines and Illinois rivers, the lowering of the lake level and the present topography of Cook county. The principle underlying the Chicago drainage problem is then clearly understood and an eminently practical value is given to the study. The missionary work done by this one subject is very great, for the pupils invariably instruct their parents who are generally as ill-informed as the pupils themselves.

While the field work is going on, two days of the week are devoted to that phase of the work, observation and discussion thereon—the remaining three are devoted to a study of mineralogy and lithology. The work is purely experimental, the general line of Winchell's Excursions and Crosby's Common Rocks and Minerals being followed. The properties of the minerals and the characteristics of the rocks are not learned from the book, but from actual tests, and are tabulated for use in future investigation. Only those varieties are studied of which there are in the school cabinet enough to supply the entire class with one or more. The cabinet is somewhat peculiar in that it has been formed for this particular kind of work. It contains few really beautiful specimens and none for show, but has fully five hundred specimens of quartz in most of its forms, a hundred of the feldspars, an almost equal number of the micas, fifty garnets, seventy-five staurotides and others of the commoner varieties in almost equal abundance. As soon as the pupil acquires a knowledge of a few varieties he is required to select these, and give reasons for his selection, from a larger number that he has not yet studied. Thus he learns to discriminate between what he is sure he knows and what he is sure he does not know. Each day he adds to his knowledge by the study of a new mineral or rock, till finally his work consists of identifying a fresh box of assorted specimens each day. Soon they become so expert that they can identify and describe accurately all the varieties of minerals and rocks they will probably ever find and can with some study identify new varieties. The limited time—ten months—given to geology demands that the work on minerals and rocks shall stop at this point. The sand dunes on the lake shore, the wearing away of the crust by the waves, the glaciated surface of the bed rock at Stoney island, each starts inquiries upon atmospheric and aqueous agencies and the Glacial period. These

are treated separately and topically, not from a single text book, for the class has none, but through references to the standard works most of which are in the school library, and to such geological reports as we possess, viz.: of Indiana, Wisconsin, Ohio, the U. S. government, and some of the Illinois reports.

This ends the first great division of the geological year. The aim is to begin with the known and observed, going on to the unknown and unobserved; from facts to theories; it gives free scope to the proper use of the imagination by furnishing the pupils data from which they may construct new forms and conditions; it teaches them to observe carefully, to reason inductively, and, what is of the most consequence, it teaches them that geology is not a bookish study, though books are profitable, but primarily an out-door study; and by explaining the geological history of their environment, in a simple and conclusive manner, it makes the subject realistic and ennobling.

The next phase is more theoretical—the evolution of the solar system. Beginning with the nebulous mass they trace out in succession the first rotary motion, the formation of rings of planets, of moons, the gradual cooling and the formation of the earth as a separate body. Then taking the earth as a whole they follow its history through the primeval era, the fire-formed crust, till the first land arose. Igneous agencies are studied in detail at this point. Attention is then directed to North America as a whole. Step by step the growth of the continent is followed. Geological maps of the continent at different epochs, geological sections and maps of particular regions are made. This part of the work is done slowly and with great care, so as to give the pupils a very clear idea of the gradual growth of the continent. Following this general view comes a study of the eras individually, their rock characteristics and fossil remains; then each era is divided into ages and these studied in a similar manner; then the periods and groups. It might be supposed that this would result in mere word learning. Such is not the case, however. The school cabinet contains samples of rocks and fossils illustrating nearly all the formations from the Laurentian to the Tertiary. The Mesozoic, though, is but little touched upon compared with the work done on the Palæozoic—an unfortu-

nate state of affairs, perhaps, but due to the fact that we have very little material from the Mesozoic. When the Hudson River group is reached there is material in abundance—a bushel or so of fossils and hand specimens from Richmond, Indiana. Each pupil then begins the systematic study of palæontology with a large box filled with a variety of fossils representing the commoner species. In filling these boxes care is taken that each pupil shall receive not merely an assortment of species but a dozen or fifteen specimens of each kind. These they first arrange in their own way by making piles of those that seem to them alike—a method for beginning that never fails to arouse their enthusiasm and cultivate their power of observation. At first their power to see differences and likenesses is very slight. They distinguish between *Streptelasma corniculum* and *Strophomena alternata* but not between *S. alternata* and any species of *Streptorhynchus*. *Orthis biforata* and *Rhynchonella copax* they separate, but *Orthis occidentalis*, *Orthis sinuata* and *Orthis subquadrata* lie side by side in the same pile; the corals are to them absolutely one species. When they have done all they are able to do in this way they are taught to separate the corals from all the rest; then the trilobites, and generally have nothing left but molluscs. These they again separate till they get to the genus, species and variety. When at last they get to *Strophomena alternata* var. *fracta*, they know every distinguishing feature about it, and the reason for every term that can be applied to it correctly. After the work of classification is finished they go still farther with a few e. g. *Streptelasma. corniculum*, *Strophomena alternata* and *Orthis biforata*, studying in detail their internal as well as external characteristics. Similar work is done with Coal Measure fossils from La Salle, Illinois, and would be done with the Niagara fossils were it not for the impetuosity of youth, for in their rambles they find many Niagara fossils and their zeal is quite hot enough for identification at once. Consequently the remains in the Niagara are studied at almost all times in the year, though in the proper place the study is reviewed. The three groups mentioned are studied more carefully than the rest, merely because we happen to possess an abundance of material. Other groups would do as well. It must not be supposed that each point touched upon in this outline is treated exhaustively

—that would require a lifetime, but the most salient features are, at all times, the only ones noticed, so that the power to expunge becomes quite as useful as the power to insert. After the different groups are in turn studied the pupil finds himself at the point from which he started—the Glacial period. The old plan of beginning with the Archean because it was the first in point of time has no good reason to sustain it, especially if the pupils are immature. The error comes in supposing that the order of instruction must coincide with the development in order of time—a supposition to which the most charitable rejoinder is that it is an egregious blunder. The young mind must begin with that which can be seen, be handled and experienced. The crude materials must be furnished the mind else there can be no proper use of the higher functions of imagination, reason and judgment. Hence the practical, also the psychological, order is to begin with the home geology, then going to the broadest view possible, the nebulous mass as a whole, then in turn, the earth, North America, and the particular region in which the study is pursued, keeping in mind the bearing of each new phase upon evolution and the progress of life from *Eozoön canadense* (if it be a form of life) to man as the crowning glory of all.

THE PHOTOGRAPHIC SURVEY OF A STATE.

By Moritz Fischer.

During the progress of the geological survey of a state, a large amount of material is accumulated which usually serves as base for a state museum. Most of our state museums have originated in this manner; the very nature of their origin is still upon them; they illustrate the geology and economic resources of their respective states.

Such a museum is of great value; its collections form a library to which resort both investor and man of science for accurate and reliable information.

Now, while the material benefits resulting to a State from its museum may be demonstrated in dollars and cents, said museum possesses educational possibilities which have but rarely been utilized, and when the attempt has been made it has resulted in at least partial failure chiefly due to want of a natural base and background upon which to organize and against which to place the collections.

This base is man and the land upon which he dwells, the reciprocal influence of both, a relation from which sprung all civilizations and which with its attendant phenomena might well be called cultural geology.

To represent these relations no art is better qualified in every way than that of photography. Below is given an outline of the photographic survey of a state which presents the relations stated above in their natural sequence and which, it is hoped, may serve as a guide to those interested in such work.

The photographs intended for museum purposes should all be on glass; and if the process of coloring transparencies of which such beautiful examples were shown by the U. S. geological survey at the Cincinnati Centennial, can be economically employed, a perfect and ideal representation of a commonwealth and all that is embraced within its domain, becomes a possibility.

It is evident that the result of such a survey can be utilized in a good many ways. For a home or foreign exposition nothing more desirable could be asked. All the numerous demands for accurate illustrations required by the many professions and arts of the day can well be supplied from this source. The employment of this material for home decoration is another possibility. Perfect in color and outline, light and shade, these transparencies should replace the sins in color and form called chromos which now "adorn" our dwellings.

Scheme for the Photographic survey of a state.

Land.	Water.
Physical features due to formative action of water.	Physical features due to destructive action of water.

Virginal surface and the life it sustains.

Mineral kingdom. Plant kingdom. Animal kingdom.	=	Phenomena of life and all that pertains thereto.

Civilized man.

- Life of the individual.
- Social relations of the individual.
- Individual and his surroundings.
- Individual and his domestic animals.
- Individual as a handworker.
- Individual as a brainworker.

Aggregation of individuals. Commune.

- Primitive commune.
- Commune and its attributes.
- Commune and its social life.

Segregation of communes.
Commonwealths.
- Agriculture.
- Resources.
- Industries.
- Manufactories.
- Transportation

In many of our states man now begins to occupy virgin soil; here can be seen the very beginning of civilization; its gradual development and all its varied phenomena can yet be permanently fixed and gathered, constituting a treasure the like of which is not in possession now of either individual or commonwealth.

ON A POSSIBLE CHEMICAL ORIGIN OF THE IRON ORES OF THE KEEWATIN IN MINNESOTA.

Read Sept. 2, 1889, at the Toronto meeting of the American Association for the Advancement of Science.

By N. H. Winchell and H. V. Winchell.

The proper understanding of the limits of this discussion requires a brief statement of some recent stratigraphic determinations. It is evident that the papers of the late Prof. R. D. Irving[1] and of Prof. C. R. Van Hise,[2] while in the main considering the problem from the point of view of the "Huronian," have also embraced in the scope of the phenomena cited, a group of strata much older, which lie everywhere[3] unconformably under the Huronian, and which present a series of facts which are distinct from those appertaining to the Huronian as found in the Penokee-Gogebic and Mesabi regions. The confounding of two formations, and the placing in one category the chemical and structural phenomena that are separated into two series by a great time interval, and by structural unconformity, have so complicated the problem that hitherto no theory has been found capable of covering all the facts. The existence of this widespread unconformity has been shown in recent reports on the geology of the northwest by A. C. Lawson, A. Winchell, and by the writers; and latterly it was also recognized by Irving (7th An.

[1] *Am. Jour. Sci.* (III.) XXXII. 255.
[2] *Am. Jour. Sci.* (III.) XXXVII. 32.
[3] Compare the Seventeenth annual report of the Minnesota survey, pp. 42-45.

Rep. U. S. Geol. Sur.) By Prof. Irving, however, there had not been, prior to his death, so far as known, any reconstruction or limitation of his general theory of the origin of the iron ores.

It is the purpose of this paper, while not calling in question the explanation by Irving of the origin of the ores of the Huronian, to show specifically a possible origin for those of the Keewatin as they are found in the Vermilion range in northeastern Minnesota.

That there is reason to account for the Vermilion ore on a different hypothesis from that which may be sufficient for the Huronian ore, is evident from a consideration of the following differences in the formations: The Huronian strata are of fragmental origin, accumulated by the slow process of sedimentation and are siliceous; being banded by lines of deposition that fade from one sort to another by such insensible transitions as can be produced by successive variations in the forces of an ordinary sedimentary process. This structure not only pervades the rock that embraces the ore, but passes into the ore itself. The formation as a whole, and certainly the beds that embrace the ore, are made up of secondary grains derived from some other formation. In other words it is non-crystalline. (Irving, 3rd An. Rep. U. S. Geol. Sur. pp. 157-165; 16th Report, Minnesota survey, p. 39.)

On the other hand the strata that carry the iron ore deposits of the Keewatin are,when not rotted in situ, crystalline or subcrystalline, and do not vary in composition like a sedimentary rock. They do not show except very rarely, any transitions between the ore and the enclosing rock, and when they do show such a mingling the alternations are between two kinds of materials, and without intermixture of clayey substances. The two materials are the *ore itself* and the *country rock*. But the country rock is uniformly constituted of diabasic schist which shows either its direct origin from eruptive, basic rock or its quick distribution and deposition in waters heated by volcanic disturbances; and but rarely has so much intermingled silica, of secondary sedimentary derivation, as to raise the per cent of silica above the limit of Von Cotta for a basic rock. At points remote from the ore lodes the proportion of silica increases, and it is besides not wholly of the characteristic chalcedonic sort that prevails in the ore and in

proximity to the ore. But, instead, some part of the silica found in strata distant from the ore lodes is in the form of rounded grains of vitreous quartz such as is chemically deposited in ordinary quartz veins. Besides silica, an aluminous element also displays itself in the formation at points removed from the mines.

Another noticeable difference between the Huronian and the Keewatin ores consists in the gradual changes that are seen to occur in the Keewatin ore as the country rock becomes more and more crystalline, massive and diabasic. In passing eastward from Tower the hematite is seen to give place gradually to magnetite, *pari passu*, as the green schists assume the character of unmodified diabase; and in the vicinity of Snowbank lake the iron ores are magnetic jasperoid lodes embraced in such massive diabase,[4] conforming in general with the strike of the rocks of the region, and still showing all their necessary relations to the Keewatin formation. These characters are found, not in the lower, often lake-filled valleys, but on the hills at elevations of several hundred feet. No such phenomena have ever been reported from the Huronian. The eruptive, diabasic rock of the Huronian mines, either underlies the iron-bearing strata unconformably, as described by Dr. Rominger, or is in the form of transverse dikes that cross both the country rock and the ore beds, as recently described[5] by Van Hise.

Not only in respect to age and geological relations do these ores differ, but chemically they are quite different. The points of dissimilarity stand prominent in making a comparison of their impurities. The Keewatin ores contain silica as their chief impurity, the amount of phosphorus, determining the Bessemer or non-Bessemer grade, not being noticeably different from the Huronian ore. But in respect of other impurities the Huronian ores contain about 300 per cent. more manganese, about 400 per cent. more sulphur, about 33 per cent. more alumina, about 25 per cent. less of magnesia, about 400 per cent. more lime, and about 400 per cent. more water.[6] The Huronian ore is generally soft, and sometimes is a limonite passing to siderite. The Keewatin ore is hard, never limonitic, and has not been known to contain any carbonate of iron.

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[4] Am. Geol. Jan. 1889. p. 19; *17th Rep. Minn. Sur.* p 122.
[5] C. R. Van Hise. *Am. Jour. Sci.* (III.) XXXII. p. 32.

The objections to the eruptive hypothesis of Foster and Whitney, lately revived by Dr. Wadsworth, have been stated in the fifteenth report of the Minnesota survey, and it is not necessary to dwell on them here. The extreme length to which Dr. Wadsworth is carried by his predilections for eruptive agencies is seen in his arguing [7] that the quartzyte at Republic mountain is eruptive. One of the chief obstacles to this theory is the novelty of the proposition to enclose fused silica in the same mass with crystalline hematite and require them to cool without chemical union, the former retaining an amorphous state and the latter not losing its crystalline structure. Another obstacle is the plainly sedimentary banding that the ore presents—i. e. the jaspilyte—which is unlike any structure known to result from the cooling of molten rock, and which unmistakably reveals the action of water in the formation of long parallel bands or strata.

The difficulties in applying the theory of Irving, i. e. the metasomatic substitution of oxides of iron for some preëxisting carbonate, appear when we search for the remains of the supposed older carbonate, and when we find the country rock does not afford good reason to have expected the deposition of any carbonate; and also when we search for the remaining ingredients which the assumed metasomatic process may have left in the ore. In short, the whole mass of geological and mineralogical environment, as seen in the Huronian rocks, is at variance with that seen in the Keewatin, and precludes the hypothesis that ordinary chemical substitution will account for the chalcedonic silica and the hematite of the jaspilyte lodes.

But that chemical processes played a prominent if not a principal part in the formation of the jaspilyte, and in the metamorphism of the strata of all the Archean, there is no disposition to call in question.[8] It is here appealed to as the prime agent in giving origin to the chalcedonic silica and the iron ore of the jaspilyte.

In order that the physical circumstances which obtained during the age of the crystalline and sub-crystalline schists,

[6] These results are based on average analyses for 1888, published by Pickands, Mather & Co., derived from several thousand assays.

[7] Notes on the Geology of the Iron and Copper districts. *Bul. Mus. Comp. Zool..*, Geol. ser. vol. I. p. 54.

[8] A. Winchell. *Fifteenth Report Minnesota survey.* p. 196.

i. e. during the age of the Vermilion and of the Keewatin, may be fairly apprehended, and brought to bear upon this inquiry, it will be necessary to mention some inferences that have recently been wrought out by the study of the Archean.[9]

It has been stated repeatedly by G. M. Dawson,[10] by A. C. Lawson[11] and by the writers,[12] that the rocks of the Keewatin consist very largely of volcanic ejectamenta. These ejectamenta were received in oceanic waters. The volcanoes themselves were mainly sub-marine, and the products of any intervening stage of sedimentary quiet were buried under the lavas of the next quickly succeeding stage of eruption. Whether this eruptive age was world-wide, in its production of this kind of basic schist, as seems very likely, it is not necessary here to inquire; but that it was one of long duration, and prevailed in all of northeastern Minnesota wherever this rock horizon has been examined, and extended into Manitoba, there is no longer any room to doubt. It is therefore necessary to inquire how such products as chalcedonic silica and hematite could have been formed in a sea that was at times seething and steaming with volcanic craters and earth fissures from which escaped molten rock from below the thin crust. That this chalcedonic silica, involved closely with interbanded hematite, and grading to hematite by insensible variations in the amount of iron present, was received in water and distributed by water is indicated not only by the stratiform arrangement, but also by the presence, occasionally but very rarely, of rounded grains of other silica, not chalcedonic, some of them being a quarter of an inch in diameter, embraced in the general mass of the jaspilyte, and sometimes forming more or less distinct bands or pebbly patches in the jaspilyte, approximately parallel with the general strike. This fact effectually vetoes the eruptive theory, and demonstrates that there was no exception in favor of that theory so as to produce a structure characteristic of sedimentation, through the agency of molten acid lava flows.

When the character of some of the narrow bands of pure

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[9] *Seventeenth Annual report Minnesota survey.* pp. 37-40.

[10] *Geology and Resources of the 49th parallel.* 1875. p. 52.

[11] *Geology of the Lake of the Woods. Can. Survey Rep.* 1885. C. pp. 49-54.

[12] *Fifteenth Report, Minnesota survey.* 1886. p. 221; *Sixteenth Report,* p. 108; *Seventeenth Report,* p. 37; Am. Geologist, Jan. 1889. vol. III. p. 22. Compare also Foster & Whitney on the "Azoic;" *Report on the lake Superior land district,* 1851. Part II. p. 67.

white and translucent silica is duly considered, and it is compared with the known product of *chemical precipitation* from siliceous waters, the idea of chèmical precipitation is forcibly presented as the possible origin for the chalcedonic silica of the jaspilyte. There is no way known in nature for the formation of chalcedonic silica except chemical deposition. The different bands of the jaspilyte, varying in color from white to red, brown and sometimes nearly black, are all formed by the varying proportions of hematite and silica. Ordinary sedimentary action could not select from the products of erosion simply two substances and unite them in characteristic strata, when the ocean's waters must have been heavy with suspended matter of many different kinds. Some selective, discriminating force was at work which was able to abstract silica, or silica and iron oxide, from the water, and reject all the rest.

In the light of what has already been said regarding the nature of the schists enclosing the ore masses, it is plain that the waters of the Keewatin ocean were constantly agitated by volcanic eruptions. It is also plain that they must have been hot, and in some places, or after irregular intervals of time, they must have been probably evaporated, and at other times suddenly cooled. The earth's crust was thin and easily rent, and the contact of water and molten rock was frequent. The waters became alkaline by solution, from the lavas, of the magnesia, potash and soda, and other alkaline elements. In this condition it would also become surcharged with soluble silica and iron, obtaining the latter from the augitic minerals of the basic lavas, and possibly from masses of erupted metallic iron. Indeed the ocean was a hot, compound decoction of all the minerals that could be dissolved from the eruptive diabases; and of those minerals there was no exception.

Under such circumstances it requires no extensive research nor chemical foreknowledge to predict what would be the result whenever the equilibrium of super-heated and supersaturated oceanic water was disturbed. Something would be precipitated. Would it be silica and ferric oxide?

On this point Hunt says:[13] "The atmosphere, charged with acid gases which surrounded this primitive rock, must have

[13] *T. Sterry Hunt, The chemistry of the primeval earth, Am. Jour. Sci.* Jan. 1858. *Smithsonian Report*, 1869, p. 189. *Chemical and Geological Essays*, 1878, p. 40.

been of immense density. Under the pressure of such a high barometric column condensation would take place at a temperature much above the present boiling point of water; and the depressed portions of the half-cooled crust would be flooded with a highly heated solution of hydrochloric and sulphuric acids, whose action in decomposing the silicates is easily intelligible to the chemist. The formation of chlorides and sulphates of the various bases *and the separation of silica* would go on until the affinities of the acids were satisfied, *and there would be a separation of silica taking the form of quartz*, and the production of a sea water, holding in solution, besides the chlorides and sulphates of sodium, calcium and magnesium, salts of aluminum and other metallic bases. * * * * Quartz has not only never been met with as a result of igneous fusion, but it is clearly shown by the experiments of Rose, that a heat even much less than that required for the fusion of quartz destroys it, changing it into a new substance which differs both in chemical and physical properties from quartz. * * * The first precipitates from the waters of the primeval sea must have contained oxidized compounds of most of the heavy metals. The large amounts of silica contained in solution in the waters of some thermal springs and of many rivers, are separated when these waters are exposed to spontaneous evaporation, partly as silicates of lime and magnesia, and partly in the forms of crystallized quartz, hornstone and opal. In many different formations, beds are met with composed entirely of crystallized grains of quartz which have apparently been deposited from solution. In other sediments this element abounds in the form of grains of chalcedony, or as amorphous soluble silica. The beds and masses of chert, flint, hornstone, buhrstone, and many jaspers, have all apparently been deposited from aqueous solutions."[14]

Prof. A. Winchell thus refers to this primeval ocean and the precipitation of silica:[15] "The liberated silica would separate and would be chemically precipitated during the subsequent cooling of the waters, and would thus give rise to the enormous beds of quartz which we actually find among the very oldest strata."

Concerning the similar production of beds of iron oxide,

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[14] Hunt. *Geology of Canada*, 1863. p. 574.
[15] A. Winchell. *Sketches of Creation*, 1870. p. 59.

Hunt states:[16] "Those chemical compounds which were most stable at the elevated temperature then prevailing would be first formed. Thus, for example, while compounds of oxygen with mercury, or even with hydrogen, could not exist, oxides of silicon, aluminum, calcium, magnesium and iron, might be formed. * * * * All the elements, with the exception of the noble metals, nitrogen, chlorine, the related haloids, and the hydrogen combined with these, would be united with oxygen. The volatility of gold, silver and platinum would keep them still in a gaseous condition at temperatures where silicon, and with it the baser metals, were precipitated in the form of oxides."

These quotations might be multiplied. The formation of siliceous and irony deposits from oceanic waters is referred to by Gustav Bischoff,[17] J. W. Dawson[18] and by nearly all geologists who have written of the chemical reactions of the primeval ocean. Much speculative literature has been published relating to the early co-relations of the consolidating crust, the heated interior and the enveloping atmosphere of the earth. But very often no actual account has been taken of these theories in the practical work of the field-geologist. The drama of sedimentation and the erosion of shores and the transportation of material by currents, forming the later strata of the super-crust, have been duly investigated, but this theoretical age of seething, alkaline, oceanic water, the actual causes that produced it, the resultant rock that attests its existence, and the position it holds in the strata of the Archæan, have not had their analogous demonstration and adequate description in geological literature. The writers believe the Keewatin age was characterized by these forces and events, and that the green schists, whether sericitic, or chloritic, or diabasic, that fundamentally constitute the bulk of its rocks, and the jaspilyte lodes, exemplify the chemical precipitations and mechanical depositions that the theories require. So long as the term Huronian was made to cover the actual Huronian strata as well as all lower beds down to the Laurentian base, it was difficult, if not impossible, to invoke world-wide forces

[16] T. Sterry Hunt. *Smithsonian Report*, 1869. pp. 186, 189.
[17] *Chemical and physical geology*. (Cavendish Society). vol. I. pp. 143, 146.
[18] *Quart. Jour. Geol. Soc.* vol. v. p. 25.

in one portion of the stratification that nullified those that were demanded to produce the rocks of the other. By the separation of the Keewatin from the Huronian, a different set of conditions may be relied on, but none other than those needed to produce the rocks that are found to compose it.

It is not the purpose of this paper to explain any of the physical conditions of the jaspilyte, nor of the strata that compose the bulk of the Keewatin, such as brecciation, folding and involute contortion, compression, fracturing and transportation of strata once formed, the upheaval and prevailing verticality of the beds. These, in the main, must have been produced subsequent to the chemical precipitation here appealed to to explain their origination, but to a certain extent seem to have been cotemporary with the precipitation of the beds themselves. But it is our sole purpose to account for the existence of the jaspilyte by some hypothesis consistent with known chemical laws, and in accordance with such surroundings and physical forces as the nature of the Keewatin rocks shows to have obtained at the time of its formation. This hypothesis not only is consistent with these laws and conditions, but it explains some of the features of the jaspilyte which no other theory, so far proposed, will explain. Some of these peculiar features may be mentioned, namely: *first*, It accounts for the minutely fine structure of the silica, and for the uniformity of its granular texture on disintegration; *second*, It accounts for the prevalence of this structure at all depths in the earth, wherever the jaspilyte is found to extend; *third*, It accounts for the agate-like banding and the minuter lamination that characterize the jaspilyte; *fourth*, It furishes an explanation for the purity of the white chalcedonic ribbons, which consist of silica only; *fifth*, It explains the re-cementation of some of the thin, brecciated layers by material of the same kind as the layer itself; *sixth*, It explains the occasional intrusion of rounded grains of non-chalcedonic quartz into the mass of chemically precipitated quartz; *seventh*, It explains, lastly, the occasional mingling of chalcedonic silica with the finer elements of the basic schists, forming regular sedimentary alternations.

Summary. All attempts hitherto made to account for the existence of the iron ores of the northwest, particularly those of Profs. Irving and Van Hise, have confounded the phenom-

ena of two unconformable formations that manifest constantly distinct contrasts of stratigraphy and lithology.

The theory of Foster and Whitney, that these ores are of eruptive origin, is opposed by chemical laws, and by structural peculiarities that can not be reconciled with it.

The ores of the Keewatin are markedly different from those of the Huronian in their chemical impurities.

The theory of metasomatic substitution of iron oxide for some carbonate, while applicable to the ores of the "Huronian" on the south side of lake Superior, cannot be made to account for the ores of the Keewatin, because, (1), There is no evidence of the existence, at any time, of the necessary earlier carbonate, and (2), The nature of the country rock embracing the Keewatin ore is such as to imply that no carbonates, in the amounts required by the theory, could have been deposited at the time the rocks were being formed. There is therefore necessity for some other explanation than that applicable to the "Huronian" ores.

Chemical precipitation in hot oceanic waters, united with simultaneous sedimentary distribution, might produce the Keewatin ores in a manner consistent not only with the physical conditions that prevailed at the time of their formation, and with the structural peculiarities which they exhibit, but also in accordance with the known reactions of heated alkaline waters, and with the chemical character which the ores are known to possess.

University of Minnesota, August, 1889.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Solar heat, Gravitation and Sun-spots. J. H. KEDZIE.* The author's view of the nature and cause of gravitation is derived directly from his theory of Solar heat, as already presented. Without rejecting, or even modifying, anything taught by Newton as to the laws of gravitation, Mr. Kedzie offers a theory as to its cause and its mode of operation. Newton did not discover its cause, nor attempt to explain its mode of action, but the great revelation that came to him referred only its law.

The prevalent conception of gravitation gives every particle of matter the power to reach out and draw every other particle toward itself. This idea the author not only questions but denies and disproves, and

* See pp. 181, 246, for other portions of this review.

quotes the authority of Newton himself, who denied with emphasis the possibility of any such energy as residing in the particles of matter. The theory of the author is considered under two heads: (1) The efficient cause of gravitation, and, (2) The mode of its operation.

The waves of heat that radiate from the sun, and all suns, carried through space by the undulations of the universal ether, undergo such modifications that they appear under the guises of several specialized forms of force; one of them being mechanical force, or that infinitesimal impact which each particle of each moving wave bestows on the particle of matter with which it comes in contact. This specialization of the energy that is carried in the waves of the ether operates in all directions and in right lines, without interference with itself. They are the impulses that matter transmits, through the ether, to other matter, the beginning of which is coëval with the beginning of things. Thus while the seat of gravitation is in the ether, the ether is only the proximate cause, the transmitting cause. The cause itself is in other matter, but that again acts only as it is acted upon by other ether. Hence the operation is a round, from cause to effect, which again become a cause and an effect, and so on ceaselessly.

As to the mode of action of gravitation—As matter intercepts some portion of the impulse of a wave of ether that impinges upon it, the leeward side of such a mass is in a shadow from that amount of impulse, and if another mass happen to be in the line of that shadow it is sheltered on that side. Indeed they mutually shelter each other from those impulses that would pass in right lines through both. In other words the impulses that impinge on their unsheltered sides drive them together, and the force with which they approach each other is gravitation. Every particle of matter is thus impelled toward every other particle by propulsive forces varying directly as the masses and inversely as the square of the distance between their centres. The machinery of the planetary systems, as outlined in astronomical mathematics, would move on as smoothly under the sway of a universal propulsive force, as of a universal attractive force, and all the laws of astronomical physics, so far as they would be needed to maintain the universal motion, would be as rigidly observed. "Let a large round table be placed in the middle of a room; place a wooden globe in the centre with any number of equidistant radii composed of rigid rods projecting from its equator. Station around it an equal number of boys, of exactly equal strength, one to each rod. No matter wheth- they all push or pull, the pushes or pulls will neutralize each other, and the globe will remain unmoved. But this is not the case with the earth. She is slowly, compared with her onward motion, falling toward the sun. * * * * If we suppose the boys to be pushing on this wooden globe, we must, to adapt the comparison to the case in hand, withdraw one of the boys, say from the south side of the table, then if all the remaining boys push with equal force, the globe will slowly move toward the side of the table where the resistance is the

smallest." This illustrates the tendency of the earth toward the sun, the boy withdrawn from the south side comparing to the ether waves of mechanical force intercepted from the earth by the sun. No account is taken here, of course, of the tangential force which maintains the earth in its orbit, and prevents its flight direct to the sun. But it is obvious that when a sufficient number of other planets and suns, each intercepting waves of mechanical force that pass through the celestial spaces, are adjusted in proper relations about the earth when it starts on its journey direct to the sun, its path would be so modified that the endless circle of its orbit would be the result.

The author, by various illustrations, shows this theory is sustained by astronomical arguments, and by the demands of the law of correlation and conservation of energy, and then enters upon a comparison of gravitation with light and heat. He notes first five resemblances, viz:

1. Light is unquestionably a vibration or quivering of the universal ether. Gravitation must necessarily act through the same medium, from sheer want of any other, and just as necessarily by means of vibrations, as the ether can not act by actual transference of its substance.

2. Light diminishes in intensity as the square of the distance increases. Gravitation does the same, but with a marked distinction.

3. Both light and gravitation are regarded by all as emanating in their incipiency from ordinary matter.

4. The combined force of light and heat, and the force of gravitation, are both forms of energy convertible in turn into all the others.

5. These two forms of energy, like all other forms, are subject to the laws of conservation and correlation.

These resemblances justify a suspicion at least of a closer relation than has hitherto been accorded them. Notable contrasts are as follows:

1. Gravitation acts as powerfully at the poles as at the equator. Not so light and heat.

2. Light diminishes as the square of the distance increases, only per unit of area, and not at all in quantity. It is spread out thinner, but it is not lost, and could all be reconcentrated by a convex lens. Not so gravitation.

3. Light at any distance from a luminous body can neither be increased or diminished in quantity, but only dispersed by divergence, and is strictly limited in amount. Not so gravitation; for gravitation is practically infinite. It handles Jupiter as easily as the earth or as any of the asteroids. It is everywhere, and in sufficient force to do any work required of it.

4. Heat penetrates, as heat, but a comparatively short distance in the inter-stellar spaces. Even as light it fades out, when the distance is great enough. Not so gravitation, for the emanations from the fixed stars, which are infinite in number, penetrate to the earth as cold

waves of gravitation, whereas if those emanations had remained unchanged, their numbers would be sufficient to flood the earth with insufferable light and heat.

5. We reckon the dispersion and divergence of light and heat from some point on the surface of the luminous body, but we reckon gravitation from the center of the mass. These resemblances and contrasts are all beautifully accounted for on the supposition, as required by the author's theory, that the undulations that produce light and heat are *outward, from the sun*, and those that produce the resultant motion we call gravitation an *inward toward the sun*, the latter originating from the surrounding spheres, infinite in number and infinite in their power, sufficient to cope with any mass they may encounter, although starting from their sources as highly luminiferous and thermaniferous, perhaps, as those that issue from our sun.

(TO BE CONTINUED.)

Structures et Classification des Roches eruptives. Par A. Michel Lévy, Paris, 1889. 8vo. pp. 95.

This memoir is, in effect, a detailed review of the second edition of Rosenbusch's *Mikroskopische Physiographie der massigen Gesteine.* It bears the impress of a master hand. American students have been drawn to the study of the German experts in modern petrography, and to a large extent, have become partisans of the German school. Among the Germans, Rosenbusch seems to be conceded the first place, and it is impossible to deny that his great work embodies a vast amount of compilation and original research. It will be useful however, to bear in mind the fact that the splendid quarto volumes of MM. Fouqué and Lévy appeared in 1879, and that the results which that work embodies began to see the light as early as 1874. The first edition of Rosenbusch appeared from 1873 to 1877; but the second edition, which has inaugurated the revolution in petrography, dates from 1887. Not only is this priority of publication due to MM. Fouqué and Lévy, but the student of their writings will discover valid grounds for M. Lévy's claims as set forth in this review, to priority of conceptions and of terms.

To illustrate the case, we may introduce a few specifications: Rosenbusch's distinction of rocks into *holocrystalline* and *hypocrystalline* corresponds very nearly to Lévy's distinction into *granitoid* and *trachytoid* (or *porphyric*). This conception was announced by Rosenbusch only in his new edition, but by Lévy it was announced in 1874, and again in 1875. The *microgranulites* of Fouqué and Lévy presenting passages to a granitic structure, but without the habit of granites, have been renamed *microgranites* by Rosenbusch, though referred to his group of *quartz-porphyries*. The term *petrosilex*, as used by authors, is changed by Rosenbusch into *microfelsite*. Vogelsang had denominated as *granophyres*, those quartz poryphyries with a granular magma, as *felsophryes*, those with a petrosiliceous magma, and as *vitrophyres*, those with a vitreous magma; but Rosenbusch changes the term granophyre from its original signification by embracing under it the three

petrographic forms of Vogelsang, and thus displacing Lévy's *micropegmatite*, which has precisely the same meaning. Again, professor Rosenbusch recapitulates the structures of palæovolcanic rocks as a *felsite habit*, a *porphyritic habit*, and a *doleritic habit*; these are precisely the characters expressed by M. Lévy in the phrases *structures of acid rocks*, *structures microlitic*, and *structures ophitic*.

Such is the nature of M. Lévy's indictment for changes of nomenclature. In our judgment, very many of Rosenbusch's terms are happily chosen and expressive. Next in honor to him who gives existence to a new conception is he who gives it to the world in fit phrase. M. Lévy would undoubtedly recognize the superior fitness of many of Rosenbusch's terms; but there is ground for complaint when a change of terms brings no gain in brevity or elegance, or truthfulness, but simply bequeathes synonymy and perplexity to hinder the progress of the learner.

More important are M. Lévy's criticisms of the subject matter of professor Rosenbusch's work. In reference to the doctrine that the holocrystalline rocks have but one period of consolidation, he says: "We know of but a single series where the two periods do not exist; that is the saccharoidal granulites (structure *microlitic* of M. Rosenbusch, in which all the elements have proper crystalline forms (*idiomorph*, *pan-idiomorph*) and date from the second period, the first making almost complete default." He shows, also, that most of the idiomorphic rocks are not strictly as described. Depth is only one of the factors determining the crystalline state of a rock. "Mineralizers" often play a preponderating rôle in the structures of acid rocks. Rocks of deep origin may present a porphyroid structure in certain special circumstances where the factors of crystallinity abruptly diminish. Even granitoid rocks may have had two periods of crystallization, though the products differ little in crystalline dimensions. In the view of M. Rosenbusch, there exist a great number of gabbros and diabases in the effusive or bedded condition. But in one part of his work he makes the statement that the gabbros with granular structure are the *intratelluric form*, the diabases with ophitic structure, the *intrusive form*; the augite-porphyrites and the melaphyrs or basalts, with microlitic structure are the *bedded* and *veined* forms of one and the same magma; while, by reading attentively almost any of his chapters, we meet with all these structures and all these passages in terranes the most diverse. The explanation of this state of things is afforded by the experiments of MM. Fouqué and Lévy, who have reproduced all these structures by artificial fusion, and by baking more or less prolonged in one or two periods. With these and other considerations, it is argued that the division of "rocks of deep origin" is artificial.

More artificial is the division of intrusive rocks. Take the family of *lamprophyres*. Petrographically, they distribute themselves over the entire series, from microgranulites slightly basic, to and including melaphyrs, embracing micaceous, amphibolic and pyr-

oxenic porphyrites. Rosenbusch characterizes the family simply by the abundance of large ferruginous and magnesian crystals of the first period of consolidation. But M. Lévy claims to have been able to identify the greater part of the rocks described by Rosenbusch under the name of lamprophyres, with a rich French series comprising kersantites, dioritines, basanites and fraidronites—the traps of the old authors.

Further, in many a formation we perceive these iutrusive rocks to correspond with flows or incontestable protrusions. It would have seemed logical to remove the lamprophyres from the intrusive rocks to class them with effusive rocks. Professor Rosenbusch prefers to range a part of our French rocks in his lemprophyres of intrusive structure, and to scatter the others through all the chapters devoted to Pretertiary effusives.

In discussing Rosenbusch's views of the structures of acid eruptive rocks, M. Lévy notes that the former regards muscovite as in part, consolidated before the feldspars, but he attributes a secondary character to very recent white mica. The writer holds the greater part, even of the primordial muscovite, to be of consolidation posterior to the quartz.

M. Lévy's criticisms of Rosenbusch's doctrine of rock structures extend to many particulars, but it is not necessary to illustrate further. He gives convenient tables for comparison of his classification of structures with that of Rosenbusch. These are followed by an exposition of what is known respecting the relations which exist between the structure, the mode of formation (*gisement*) and the geologic age of rocks. The examination is then carried into the mineralogical composition of rocks, and the order of consolidation of their principal elements, considered in reference to a rational classification. He cites Rosenbusch's two principles touching order of consolidation, and maintains that they are untenable as general laws. They apply sufficiently well to granites, syenites and a part of the gabbros. But they fail entirely in the gabbros of ophitic structure, in the greater part of the diorites and the whole of one important class of diabases. In fact, the experiments of MM. Fouqué and Lévy demonstrate that for the greater part of the rock-making minerals, the order of consolidation is the inverse order of fusibility, while some of them are real chemical precipitations taking place during the period of crystallization.

M. Lévy maintains with apparent reason that the classification proposed by himself and M. Fouqué is founded on broader principles than that of Rosenbusch. The fundamental principle is that of the order of consolidation of all the rock-elements, both those of the first and those of the second consolidation. The concise exposition here given is prepossessing; while the principles of classification employed in the school of Rosenbusch are subjected to effective criticism, with which American petrographers ought at least to acquaint themselves. Comparative tables of the two classifications are presented. In another chapter we have the results of a more particular study of the subdi-

visions proposed by Rosenbusch, followed by an extended table, giving in condensed form, the subdivisions of Rosenbusch, the structures observed, the order of consolidation of the constituent elements, and the equivalent names of Fouqué and Lévy. At the end is a table giving the correspondence of the granitoid and trachytoid or porphyric rocks, according to the classification of MM. Fouqué and Lévy, with the corresponding names of Rosenbusch. The dominant idea of Professor Rosenbusch has been, according to M. Lévy, to constitute natural groups both petrographic and geologic. He has thus substituted the notion of mode of formation (*mode de gisement*) for the more positive and more relevant datum of structure. It is thus that across his three grand subdivisions of mode of formation—depth, dikes and effusives, he has sought to group, not associations chemically or mineralogically analogous, but those which he believed derived from each other by way of ramifications. It is a classification based on hypotheses, and in its ultimate consequences is not followed out by its author himself. The founders of the French school deem it necessary to base their classification and nomenclature of the rocks on facts, independent of every hypothesis, and positive in their nature. Modern petrography, they say, employs means sufficient for attaining this end without hesitation. There is general accord in reference to the principal stuctures of associations of minerals and rocks; and we know how to determine these minerals with precision. It is therefore exclusively to the structure of association, and to mineral composition that they persist in addressing themselves in the attempt to classify and name the rocks.*

Sketch of the Geology of New Zealand. By Capt. F. W. Hutton. (From the Q. J. G. Soc. London, May, 1883, pp. 191-220.) This memoir is the only published source of information on all portions of the colony of New Zealand. The islands have been studied for the last thirty years. Valuable contributions to their geology have been made by Dr. Hochstetter, Dr. Hector and the geological surveys ; but up to the date of captain Hutton's memoir, no one had attempted to describe the geology of New Zealand as a whole. The geology of the region is remarkably diversified. Sedimentary rocks of almost all ages are represented, from Archæan upward, and all but the lowest have yielded fossils. There are metamorphic and eruptive rocks. There are volcanic cones of every magnitude, up to Ruapéhu, more than 9000 feet in hight, and they are presented in all stages of degradation, from mere

* The leading authorities of the French school are as follows: Minéralogie micrographique. Introduction a l'étude des roches eruptives françaises, par F. Fouqué et A. Michel Lévy, 4to, 2 vols, text and plates, Paris, 1879. Cours de minéralogie, par A. de Lapparent, 8vo. pp. 560, with 519 cuts in the text, and a chromolithographic plate, Paris, 1888. A new edition for 1890 is announced, which we have not seen. Les minéraux des roches. 1. Application des méthodes minéralogiques et chimiques à leur étude microscopique, par A. Michel Lévy. 2. Données physiques et optiques, par A. Michel Lévy et Alf. Lacroix, Paris, 1888, 8vo. pp. 334. Traité de crystallographie géometrique et physique, par E. Mallard, Paris, 1879.

stumps to fresh scoria-cones; and two—Tongariro and Tarawéra—are still active. There are solfataras and mud volcanoes, fumeroles, geysers and hot springs in abundance. There is a mountain range with an alpine structure; there are glaciers and glacier-lakes almost equalling those of Europe. New Zealand is interesting too, from its possession of the only record of the ancient floras and faunas that once overspread the South Pacific. Being antipodal to Europe in position, the geologic results of secular astronomic causes must, in many cases, be complementary to the results occuring in Europe; so that we may look to New Zealand as a base of verification for certain hypotheses predicating causal relations between astronomic and geologic conditions. Dr. Hector and the provincial geologists make the attempt to correlate as they proceed, the geology of New Zealand with that of Europe; but captain Hutton, like Dr. von Haast, makes such attempt only after completing the survey, and determining what classification of geologic time is taught by the facts. He then places the divisions of the New Zealand scale against those of the European, and notes the equivalences. We thus have a complete system, in terms of the Maori language. The greater and less divisions are then placed in juxtaposition with the European system. It thus appears that every European "system" is recognized in New Zealand, except the Devonian. No subdivision of the Archæan is noted; and none of the Carboniferous. There is no Upper Jurassic, or Lower Cretaceous, or Eocene; but all subdivions of the Cænozoic, except the Eocene, are abundantly developed. The Oligocene is represented by five groups, the Miocene by six, and the Pliocene by six. The Pleistocene consists of, (a) Peat-mosses with Moa bones, and (b) Raised beaches and shore deposits. The Recent is characterized by alluvial and Æolian deposits, with Moa bones and traces of man. Of the events of the Pleistocene epoch, captain Hutton says: "Neither in the Wanganúi system (Newer Pliocene) nor in the raised beaches, is there any trace of a northerly migration. Neither are there any signs of a Pleistocene glaciation of New Zealand greater than at present. Consequently there is no evidence to show that the high eccentricity of the earth's orbit that prevailed in Pleistocene times, produced a glacial epoch here. But there are several facts which appear to support the view that this high eccentricity produced a diluvial epoch by causing greater winter snow-fall and greater summer floods."

On some salient points in the Geology of Queensland. Opening Address, Sec. C (Geol. and Pal.) Australasian Assoc. Adv. Sci. Sidney, 1888. By Robert L. Jack, Government Geologist, Queensland. The sparsely settled colony of Queensland, flanked by the great barrier reef of northeast Australia, dotted from limit to limit by isolated hill and mountain peaks, and belted by ridges and ranges destitute of any general trend, is one which, in the development of its natural resources, has manifested most commendable energy. We well remember the astonishing exhibit made by the colony at Philadelphia in 1876. It was

then almost undistinguished, in the popular mind, from Australia at large. During a number of years, it has maintained a geological survey, and Mr. Robert L. Jack has been in charge. The mining interests of the colony are considerable, and most of the attention of the survey has been directed to economic questions. Mr. Jack, in the years 1886 to 1889, has issued several special reports on different mining districts and localities, some of which are as follows: Report of the Argentine (Star) Silver mines, Kennedy District, 9pp; Geological observations in the north of Queensland, 16 pp; Report of the Geological features of the Mackay District, 10pp; Mount Morgan Gold Deposits (2d Report) 6pp; Coal Discoveries on the Flinders, 2pp; Geology of the Russel River, 5pp; Taranganba Gold mine, 10pp. These reports are in long quarto form, and are generally accompanied by large maps, and by sections. They are issued from the Geological Survey office, Townsville.

From the address, the title of which stands above, the geology of Queensland presents a wide contrast with that of New Zealand. Instead of a connected and complete record of physical events, we have an exceedingly fragmentary one—almost every formation resting unconformably on the underlying one. There is no certain existence of any rocks older than the Devonian. There are crystalline schists and granites, but they appear to be post Archaean. The lower and middle Devonian strata attain a thickness of about 21,000 feet. The Carboniferous rocks embrace two unconformable series holding very similar fossils. Unconformably above these, follow "Carbonifero-Permian" beds of great thickness, having volcanic agglomerates at bottom, and embracing the oldest auriferous drifts. The Ipswich formation supposed next higher, contains numerous good coal beds, and fossils of Mesozoic type, but rests, like the older groups, on slates, schists and granites. Mr. Jack sets it down as Triassic. Resting also on slates and granites, the Rolling Downs formation follows, and quite unconformably above this, occurs the Desert sandstone, once very widely extended, but now enormously denuded. Both these contain similar Cretaceous fossils, and the Government Geologist provisionally sets the one down as Lower, and the other as Upper, Cretaceous. The Upper overlaps and rests on all the older systems. The Maryborough beds, on the eastern side of the coastal range, carry a fauna which appears also to be Cretaceous, and equivalent to that of the Desert sandstone. We may conclude therefore, that during the period of the Lower Cretaceous, Australia consisted of two islands with a shallow intervening ocean, and an abrupt escarpment along the eastern shore of the eastern island, extending into a deep sea, whose deposits of that date have never been brought to light. There was then an insular epoch in the interior, and that was followed by a still deeper submergence during the Upper Cretaceous. The east shore deposits of this later period have been revealed to the Maryborough beds. On the Tertiary and later geology, Mr. Jack gives us no information.

Queensland is nearly 1300 miles in length, from north to south, and 950 miles in greatest width. It stretches from south latitude 29° to 10° and possesses, except in the southern portion, a truly tropical climate.

The Mineralogy of Pennsylvania. Part I. By JOHN EYERMAN. (To be used as a supplement in connection with Dr. F. A. Genth's "Preliminary report on the mineralogy of Pennsylvania"). 8vo. pp. 48, Easton, Pa. The author of this pamphlet brings together such discoveries of new minerals or new localities of minerals as have been brought to notice since the publication of Genth's "preliminary report," fourteen years ago, rendering a real and important service to the mineralogy of Pennsylvania. The new facts are partly his own, and partly are derived from scientific journals and published proceedings of societies. In addition to names of new minerals or localities, various descriptive notes and chemical analyses are given.

Woods mine, in Lancaster county is reported to have produced 200,000 tons of chromite, and to have netted its owners at least $5,000,000. It was exhausted after it had reached a depth of 800 feet. It was opened in 1834 and was abandoned in 1881. Since then the United States has received the most of its chrome ore from the Urals in Russia, and from Turkey in Asia. Mr. Eyerman gives localities and notes on 121 different mineral species.

In a paper on the mineralogy of the French Creek mines (*Trans. N. Y.Acad. Sci.* Jan 14, 1889) Mr. Eyerman reports an interesting variety of orthoclase. The crystals are columnar, and, radiating from a centre, form a shelf-like structure. The largest crystals seen were 64 mm in length; color, light green to light pink, the green varieties having a small percentage of manganese oxide.

Salt; its discovery and manufacture in Kansas. By ROBERT HAY. (Ex. from 6th Bien. report Kan. State Board of Ag.) It is seldom that in a brochure so small and unpretentious, so much of value is expressed as is contained in this review of salt in Kansas. After a short historic sketch of the manufacture of salt in Europe and in America, Prof. Hay states that it has been found, belonging to various geologic periods, under a great part of the surface of Kansas. The state geologists, professors Mudge and Swallow, inferred that salt would be found by boring, and referred the salt marshes, that are frequent, to the effect of the Triassic formation. The deposits that have recently been found are at the base of the Triassic, and, through the usual and well-known variation to gypsum, are probably continuous with the Permo-Carboniferous below. The review contains numerous analyses, showing that the Kansas salt compares well with that from other parts of the United States.

The "thickness of salt besides the saline shales" appears to be at Ellsworth 140 feet, Lyons 250 feet, Hutchinson 250 feet, Kingman 200 feet, Anthony 75 feet, Great Bend 125 feet and Sterling 198 feet. All the towns named are making salt or in the early stages of erecting "salt blocks."

On the production of secondary minerals at shear-zones in the crystalline rocks of the Malvern Hills. By CHARLES CALLAWAY. (Quart. Jour. Geol. Soc. August 1889.)

Dr. Callaway starts out with the proposition that the questions are to be settled rather by field evidence than by microscopic study, and asserts that the chief results were decided in the mind of the writer before a single slide had been cut." Nevertheless 150 were cut and submitted to Dr. H. B. Patton, Rosenbusch's assistant. When the reconstruction of the rock has been complete the shear planes are frequently indicated by lines of mica.

Although disclaiming micro-petrography as a necessary adjunct to this study the author hardly gets away from it during the entire length of his very interesting paper. His summary is

1. All the crystalline rocks of the Malvern chain are of igneous origin.

2. The genisses and schists are produced out of igneous rocks by secondary action.

3. The chief mineral and chemical changes have taken place in bands of rock (shear zones) which have been subjected to a shearing movement so that the metamphorism may be described as "zonal." The maximum of alteration has been produced in diorite which has been sheared in proximity to granite viens. Contact effects are here combined with dynamic metamorphism.

4. The most important chemical changes are the removal of the bases and the combination of potash with some of the constituents of diorite.

5. The chief mineral changes are the reconstruction of feldspar, and the production of biotite (from chlorite) white mica (from orthoclase plagioclase, black mica and chlorite) granular quartz, sphene and actinolite.

RECENT PUBLICATIONS.

1. *State and Government reports.*

Annual report of the Geological Survey of Pennsylvania, for 1887. Contains: Cave fossils, (2 plates), by JOSEPH LEIDY; Fossil tracks in the Trias, in York county, Pa., by ATREUS WANNER, with eleven plates; Report on the New Boston and Morea coal lands (Geological and topographical map), by BENJAMIN SMITH LYMAN, and The state line serpentine and associated rocks, by FREDERICK D. CHESTER.

The seventeenth annual report of the Geological and Natural History Survey of Minnesota. 8vo. 273 pp. N. H. WINCHELL, State Geologist. Minneapolis, 1889. Contains also reports by H. V. Winchell and ULY. S. GRANT, and a list of American publications since 1872 pertaining to the crystalline rocks.

Natural gas in Minnesota. By N. H. WINCHELL. Bulletin No. 5, of the Minnesota survey. pp. 39. 1889.

History of geological surveys in Minnesota. By N. H. Winchell. Bulletin No. 1 of the Minnesota survey. pp. 37. 1889.

3. *Papers in scientific journals.*

Am. Naturalist. May No. Soleniscus: its generic characters and relations. CHARLES R. KEYES.

The Am. Antiquarian, Sept. No., has a paper by T. H. LEWIS on Copper mines worked by the mound-builders.

Am. Jour. Sci. Sept. No. Carboniferous echinodermata of the Mississippi basin. CHARLES R. KEYES. Contributions to mineralogy. F. A. GENTH. Period of rotation of the sun. H. CREW. Grand Gulf formation of the Gulf states, L. C. JOHNSON. Note on the fossil spider Arthrolycosa antiqua of Harger. C. E. BEECHER. Paragenesis of allanite and epidote as rock-forming minerals. W. H. HOBBS. New locality of the camptonite of Hawes and Rosenbusch. F. L. NASON. Properties of allotropic silver. M. C. LEA. Ring systems and other curve systems produced on allotropic silver by iodine. M. C. LEA. Notes on some native iron sulphates from Chili. J. B. MACKINTOSH. *Oct. No.* Origin of normal faults and of the structure of the basin region. J. LECONTE. Circular polarization of certain tartrate solutions. (II). J. H. LONG. Some suggestions upon the method of grouping the formations of the middle Cretaceous, and the employment of an additional term in its nomenclature. G. H. ELDRIDGE. Some Florida Miocene. D. W. LANGDON, Jr.

4. *Excerpts and Individual Publications.*

Palæolithic man in eastern and central North America. (Part III). Reprinted from *Bos. Soc. Nat. Hist.* vol. XXIV. Embraces early man in the Delaware valley; The rock-shelter of Naaman's creek; Palæolithic implements from the Delaware gravels. By Hilborne T. Cresson. p. 141.—Implement from the Indiana gravel. By Hilborne T. Cresson. p. 150.—The age of the Philadelphia red gravel. G. Frederick Wright. p. 152.—Water-worn implements from the Delaware river. By Charles C. Abbott. p. 157.—Concluding remarks by the president with illustrations of palæolithic implements from Delaware, Indiana, New Jersey and Minnesota. By F. W. Putnam. p. 158.

On the paragenesis of Allanite and Epidote as rock-forming minerals. By W. H. Hobbs, Ph. D. *Am. Jour. Sci.* Sept. 1889.

Nova Scotian Echinodermata. D. Honeyman. Halifax.

Note on the fossil spider Arthrolycosa antiqua Harger. By Charles E. Beecher. *Am. Jour. Sci.* Sept. 1889.

The mineralogy of Pennsylvania. Part I. By John Eyerman. Easton, Pa.

Notes on geology and mineralogy. By John Eyerman. *Proc. Acad. Nat. Sci.* Phil. Feb. 1889.

On the mineralogy of the French creek mines, Pennsylvania. By John Eyerman. *Trans. N. Y. Acad. Sci.* Jan. 14, 1889.

The rivers and valleys of Pennsylyania. Wm. M. Davis. From the *National Geographic Magazine.* Vol. 1, No. 3.

The affinity of science for christianity. Prof. G. Frederick Wright. Reprint from the *Bibliotheca sacra.* Oct. 1889.

Notes on the Entozoa of marine fishes of New England, with descriptions of several new species. Edwin Linton. *An. Rep. Com. Fish and Fisheries* for 1886.

Report of Geological observations made in northeastern Minnesota. By Uly. S. Grant. Part IV of XVIIth Ann. Report of the Minnesota geological survey.

The geology of Buffalo as related to natural gas explorations along the Niagara river. By C. A. Ashburner. *Amer. Inst. Mining Engineers.* Buffalo meeting, Oct. 1888.

The development of the theories of crystal structure. W. S. Bayley. (*Am. Nat.* Apr. 1889).

5. *Foreign Publications.*

The Trap Formation of Ulster. J. Starkie Gardner. *Proc. Belfast Nat. Field Club.* 1888. Series II. vol. III. Part 1.

References to the Diatomaceous deposits at Lough Mourne, and in the Mourne mountains. By Messrs. W. A. Firth and Wm. Swanston. *Proc. Belfast Nat. Field Club.* Ser. III. vol. III. Part 1.

Verhandlungen des naturhistorischen Vereines der preussischen Rheinlande, Westfalens und des Reg.-Bezirks Osnabruck. Erste Hälfte. Bonn. 188°, contains Ueber den Charakter der quartärfauna von Thiede bei Braunschweig. Von Dr. A. Wolleman. Ueber electrolytisch abgeschiedne Kupperkrystalle, mit 2 Holzschnitten. Von *Prof. O. Mugge.* Geologisches Profil von Hamm. *J. Hendhausen.*

Transactions of the Royal Society of Canada, vol. VI. contains: Presidential address; The Huronian system of Canada. Robert Bell. Le Gaz naturel dans la province de Quebec, par L'Ubbé Laflamme' On Nematophyton and allied forms from the Devonian (Erian) of Gaspé and Bay des Chaleurs. By D. P. Penhallow (with introductory notes by Sir William Dawson). On some remarkable organisms of the Silurian and Devonian rocks in southern New Brunswick. By G. F. Matthew. Notes on the Nova Scotia gold veins. By E. Gilpin, Jr. On Cretaceous plants from Port McNeill, Vancouver's Island. By Sir William Dawson and G. M. Dawson. Illustrations of the fossil fishes of the Devonian rocks of Canada. Part II. By J. F. Whiteaves.

Chemical and Physical studies in the metamorphism of rocks. By A. Irving. Octavo, 138 pp. London. Longmans, Green & Co.

The advantage to the civil engineer of a study of geology. T. Mellard Reade. *Trans. Liverpool Engineering Society, Nov. 14, 1888.*

The New Red sandstone, and the physiography of the Triassic period. T. Mellard Reade. *Naturalist, April 1889.*

Slickensides and normal faults, their characters and cause. T. Mellard Reade. *Liverpool Geol. Society.* Session 1888-9.

Notizblatt des Vereins für Erdkunde zu Darmstadt, Folge IV. 9 H. contains: Granit und Minette an der Hirschburg bei Lauterschusen südlich Weinheim a. d. Bergstrasse, von C. Chelins. Taf. III und IV.

Chemische Analysen von tertiären und diluvialen Gesteinsarten aus den Brüchen von Weisenau und Laubenheim bei Mainz, von Dr. E. Egger. Notizen aus den Aufnahmengebieten des Sommers 1888, von C. Chelins.

Mit. d. V. für Erd. Leipzig. 1888. Contains, Die Lochaberstrandlinien, von Dr. Sandler.

On the production of secondary minerals at shear-zones in the crystalline rocks of the Malvern Hills. Charles Callaway. *Quart. Jour. Geol. Soc.* Aug. 1889.

Die ältesten Sedimente des nördlichen Schwarzwaldes und die in denselben eingelagerten Eruptivgesteine. J. H. Kloos. *Jahr. d. V. f. Naturwissenschaft zu Baunschweig. 1886-87.*

The Records of the Geological Survey of New South Wales. C. S. Wilkinson, Geologist in charge; vol. I, part I, contains the following papers:

Notes on the Geology of the Barrier Ranges District and Mount Browne and Tibooburra Gold-fields; by C. S. Wilkinson, F.G.S., Geological Survevor-in-Charge.

Report on the Discovery of Human Remains in the Sand and Pumice Bed at Long Bay, near Botany, with Plate I. By T. W. Edgeworth David, B.A., F.G.S., Geological Surveyor, and Robert Etheridge, Jr., Palæontologist.

Petrographical Notes on the Eruptive Rocks connected with the Silver-bearing Lodes at Sunny Corner, Mitchell, near Bathurst, with Plates II and IIa. By Wm. Anderson, Geological Surveyor.

On the occurrence of a Coral intermediate in structure between the Genera *Lonsdaleia* and *Spongophyllum* in the Upper (?) Palæozoic Rocks of New South Wales, with Plate III. By R. Etheridge, Jr., Palæontologist.

On the occurreuce of Tellurium in Combination with Bismuth, from Norongo, near Captain's Flat, New South Wales. By J. C. H. Mingaye, F.C.S., Analyst and Assayer.

Description of the Physical Characters of Telluric-Bismuth Ores from Norongo, near Captain's Flat. By T. W. Edgeworth David, B.A., F.G.S., Geological Surveyor.

Sketch of Columnar Basalt on the Horton river, near Lindsay Station, with Plate IV. By Henry W. Powell, Forest Ranger, Gunnedah.

Vol. 1 Part 2 contains the following:

Notes on the Mineral Resources of New South Wales as represented at the Melbourne Centennial Exhibition. By Joseph E. Carne, Curator, Mining and Geological Museum.

Note on two specimens of *Lepidodendron* from the Lower Carboniferous (?) of Goonoo Goonoo, New South Wales, with Plate V. By Robert Kidston, F.G.S., of Stirling, N. B.

On the Post-Tertiary Ossiferous Clays, near Myall creek, Bingera, with Plates VI-X. By William Anderson, Geological surveyor.

On Further Evidence of a large and extinct Struthious Bird

(*Dromornis*, Owen) from the Post-Tertiary Deposits of Queensland, with Plates XI-XIII. By R. Etheridge, Junr.,Palæontologist.

On the Stratigraphical Position of the Fish and Plant-Bearing beds on the Talbragar river, Cassilis district, with Plate XIV. By William Anderson, Geological Surveyor.

On the Examination of an Aboriginal Rock-Shelter and Kitchen-midden, at North Harbour, Port Jackson, with Plates XV-XXII. By T. W. Edgeworth David, B.A., F.G.S., Geological Surveyor, and R. Etheridge, Jr., Palæontologist.

Remarks on a Fern (*Cycadopteris scolopendrina*, Ratte), from the Wianamatta Shales, near Sydney, with Plate XXIII. By R. Etheridge, Jr., Palæontologist.

Report on supposed Caves with Aboriginal Drawings, on Harris' creek, and George's river, near Liverpool, with Plate XXIV. By R. Etheridge, Jr., Palæontologist.

Descriptive catalogue of the exhibits of metals, minerals, fossils and timbers (government and private) at the Melbourne centennial international exhibition, 1888. On behalf of the commission of New South Wales.

Handbuch der Mineralogia, von Dr. C. Hintze. 1ste Lieferung, mit 63 Abbildungen im Text, Leipzig, 1889, pp. 160. The work will form two volumes, appearing one or two parts yearly. To be completed in three or four years.

Geological Position of the "Wek-Pass Stone," New Zealand. By Capt. F. W. Hutton. *Quar. Jr. Geol. Soc.* Aug. 1885.

Correlations of the Curiosity Shop Bed, New Zealand. By the same. Ibid. Nov. 1885.

Eruption of Mount Tarawera. By the same. Ibid. May, 1887.

The Geological Record for 1880-84, (inclusive); a list of publications on geology, mineralogy and palæontology published during those years. Edited by William Topley and Charles Davies Sherborn. Vol. II. London. Taylor and Francis. 8vo. pp. 563. 10 shillings sixpence.

Taranganba gold mine. Queensland. By Robert L. Jack, Government Geologist. 1889. 4to. 10 pp.

CORRESPONDENCE.

INTERESTING NORWEGIAN GEOLOGY. *Silurfossiler og pressede Konglomerater i Bergensskifrene* af Hans H. Reusch. Kristiania, 1882. Universitetsprogram for 1ste Halvaar 1883. pp. 152. Accompanied by a colored geological map, 2 plates of fossils and 89 cuts in the text.[1]

This essay, though some years old, possesses a renewed interest for readers of THE GEOLOGIST, to whose attention similar phenomena have

[1] There is a German edition of this by Dr. H. Baldauf, entitled: Die Fossilierführenden kristallinischen Schiefer von Bergen, Leipzig, 1883.

been presented during the current year. It is a careful and detailed study of the geology of a limited district in the vicinity of Bergen, Norway. The geology in general has an Archæan aspect. The bedded rocks stand vertically, though in places much disturbed, and they embrace many varieties of crystalline schists and gneisses, associated with diorites, diorite-schists, gabbros and other forms of tufts and eruptives. The features of chief interest, however, are conglomeritic gneisses, and fossiliferous phyllites and limestones interstratified with the gneisses and crystalline schists.

These phenomena were studied especially at three separate points, Osören, Trengereid, and the mountain Ulriken. In the environs of Osören are described the following petrographic forms:

1. Quartziferous talc-mica schist; the quartz occurring partly in very small and thin lenses, and partly in larger ones, attaining occasionally a metre in length. This rock contains also layers of a finely granulated gray gneiss with very little mica.

2. Diorite schists in two zones, a northern and a southern. Both are associated with hornblende schist, chlorite schist, gneiss often rich in chlorite, granulite and green slates. The latter are sometimes so closely intersected by fine granite and granulite veins as to present the appearance of a breccia. In this connection is a rock consisting either almost entirely of coarsely crystalline hornblende or of large hornblende crystals up to a centimetre in size, scattered in a mass of fine hornblende crystals. In the granulite occur lenses of granular quartz. The hornblende schist is laminated by films of chlorite, and contains flat lenses of finely granulated feldspar varying from the thickness of paper to that of pasteboard.

3. Polygenous conglomerate, of which the constituent pebbles have been compressed until they assume in places the forms of thin lenses. Their longest dimension is in the plane of bedding, and in the direction of the strike. The least is transverse to the bedding. This rock sometimes presents a crumpled appearance. Mica and chlorite often appear in such a manner as to prove them epigenetic. Where the conglomerate has been subjected to extraordinary pressure, and mica is in abundance, its appearance is similar to that of mica schist; but where hornblende is in excess, it has the appearance of hornblende schist. These conglomerate beds are in alternation with gray gneiss, black micaceous phyllite and "eye-gneiss."

4. The "Osgneiss" (Augen-gneiss, eye gneiss) unlike the proper Augen-gneiss of the Germans, has "eyes" of whitish quartz in the midst of obscurely stratified feldspathic rock. The feldspar contains laminæ of chlorite which in some places is substituted by black mica.

5. Phyllites. These occur in two similar zones, both of which contain fossils. Accessories of dull or black mica cause incomplete transitions to mica schist, and thence to perfect muscovite schist. The phyllites contain occasional beds of fine granular gneiss; also distinct layers of limestone and small balls of dark colored limestone, with fossils changed into calcareous spar. The fossils recognized are *Halysites*

catenularia, Cyathophyllum? Syringophyllum and gasteropods resembling *Murchisonia* and *Subulites*. In the northern phyllite zone occur quartzose sandstones and conglomerates. The groundmass of one of the conglomerates is greenish chlorite. This, as well as the pebbles, is penetrated by hornblende crystals evidently epigenetic. This zone contains a great abundance of fossils, including *Graptolites*. They occur in a very lustrous shale of light gray color appearing to consist chiefly of muscovite. The rock contains weathered balls of limestone with faint traces of chain corals. In the shale occur also, *Calymene*, *Phacops*, Brachiopods and other forms indicating the horizon of the Upper Silurian. The pebbles of the conglomerates are always elongated ellipsoids and lie parallel with the strike.

6. Chloritic sparagmite, composed of small fragments of greenish, small-grained rock particles difficult to determine, and full of chlorite and black mica. Sometimes the rock has a gneissic appearance; at others the fragments are so large as to present a perfect conglomerate.

7. Calciferous gneiss. This occurs in proximity to the saussurite-gabbro.

8. Saussurite-gabbro. The structure of some portions resembles the *Riesenflaserstructur* of the Germans. It consists of lenses of gabbro of irregular grain or parallel structure. The lenses are surrounded by amphibolite schist. Mineralogically it consists of saussurite and greenish diallage. It embodies in places, fine grained, sometimes slaty, feldspar-bearing hornblende rock, and in one region becomes beautifully stratified. The latter variety is intersected by veins, and contains also, considerable masses of unstratified saussurite-gabbro. But the interruptions are not accompanied by displacements of the strata. Portions of the gabbro are rich in olivine.

9. The crystalline schists of Lysekloster appear somewhat transitional between the dioritic and hornblendic schists and a peculiar gneiss.

In the neighborhood of Trengereid are found marbles, polygenous conglomerates as at Osören, (occurring in six outcrops) several varieties of gneiss, quartzite, mica schist and *Flaser-gabbro*. In the marble are ?encrinite stems and Chain-coral. In the immediate vicinity of Bergen, the same varieties of rocks occur. Over quartz schist lies reddish and grayish gneiss. In the vicinity is a crumpled porphyritic gneiss. The conglomerate consists of a quartziferous mica schist rich in chlorite, and strewn with peddles of porphyritic gneiss-granite and other varieties of gneiss and granite.

In the Ulriken district, gneisses are the prevailing rocks; but the peculiarities of these need not here be mentioned.

The regions described exhibit the phenomena of metamorphism in a characteristic and striking development. It is beyond controversy that the marbles, phyllites and quartzites have had a sedimentary origin. The Os'gneiss is also, with little possible question, originally sedimentary. Dr. Reusch expresses the opinion that the gneisses were originally formed of loose material, (gravel of granite or gneiss)

and may even have consisted of larger pebbles of gneiss or granite. The granulite is also clearly stratified and presumably a metamorphic rock. These facts and opinions recall those presented by Dr. Edward Hitchcock in the Geology of Vermont, and those at Obermittweida in Saxony, and the conglomerates in similar situations in Canada.[2] Dr. Reusch is also clearly of the opinion that the pebbles of the conglomerates have been flattened, and in many cases stretched or elongated after being softened by igneo-aqueous action. The partially folded lenses of the green gneiss of Trengereid he regards as a pressed breccia. A brecciated condition, as he suggests, sometimes results from the presence of a multitude of thin intersecting veins; and the anomalous occurrence of a plicated bed between two unplicated beds he explains ingeniously by the slipping of one of the unplicated ones over the other, with an intervening bed which wrinkles instead of slipping bodily.

These gneissic and schistic rocks of Upper Silurian age or later, derived from indisputable sedimentary terranes, indicate, like other similar facts long known, the possibility—perhaps the probability—of a similar origin for the similar rocks occurring in sub-Cambrian zones.

Bömmelöen og Karmöen med omgivelser geologisk beskrevne af Dr. Hans Reusch. With 3 colored charts, 205 cuts in the text and an English summary of the contents. Udgivet af den geologiske undersögelske. Royal 8 vo. pp. 442, Kristiania, 1888.[3]

This elegantly printed volume contains a continuation of Dr. Reusch's careful investigations of the geology of Norway. It possesses interest, like his former memoir (noticed above) for American geologists, because much of the geology of Norway, as Macfarlane long ago pointed out, is the counterpart of the Archæan geology of Canada and the United States, and because the principles elucidated by Norwegian geology possess direct and fruitful application in the solution of problems in American geology.

The regions described in this volume extend from Bergen southward to Stavanger, including the borders of the Hardanger, Bömmel and Bokne fiords; but more particularly the environs of Bömmelö and Karmö. The rocks appear to be chiefly of Archæan, Primordial and Silurian age. Petrographically they are gneiss and granite, mostly Archæan, associated with crystalline schists, chiefly clay-slates and in places containing Primordial fossils. The fossils are sometimes in limestones embraced in the slates. Angular fragments, large and small, occur in the gneisses and granites, and the former, in numerous localities described, hold ellipsoidal, bowlder-like foreign fragments, disposed in courses, which are frequently accumulated to such extent as to result in proper conglomerates. In the forms of the fossils and pebbles the author sees remarkable evidences of compression and

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[2] On the relation of conglomerates to gneisses and crystalline schists, see the articles by A. Winchell in The American Geologist, March and April, 1889, where references may be found.

[3] See a review of this work in this journal, vol. III. p. 335.

stretching. The bowlder forms are sometimes completely flattened. Like others, he traces a connection between these actions and fissility in the rocks. The banded arrangement of the mica in certain gneissic rocks he regards as an effect of stretching; and this, he says, is often independent of the dip. Not unfrequently a gneiss and the conglomerate bedded in it are both stretched in the same direction, thus making it evident that the gneiss assumed to be stretched is really stretched. As a result of pressure certain granitic rocks assume the condition described as gneiss granite and porphyritic gneiss. The stretching phenomena have a direction parallel with the axes of the great and small folds resulting from orogenic efforts, and hence the author concludes, perhaps too readily, that the small folds and crumplings of the rocks are also an effect of stretching. But the parallelism of the stretching direction and the folding axes may have only a coincident, not a causal, relation. The orogenic disturbance of the Scandinavian peninsula is thought to constitute, with that of the British Islands, a single system, only interrupted by the subsidence of the area of the German ocean.

It is not important to notice here the distribution of the geological features of the region described; nor to refer specifically to the different petrographic features brought into view. A few points of unusual interest may, however, be mentioned. A large development occurs on the Bömmelö (island)—partly described heretofore as saussurite-gabbro—in which the evidence is that the hornblende is an ancient augite altered into uralite—kernels of diallage sometimes remaining. An associated rock is a quartz-porphyry tuff—in older descriptions called hornstone porphyry or quartzite, composed mostly of sharp-edged fragments, and evidently clastic in nature. This in other places becomes an obscure mixture of quartz and feldspar, with a granitic appearance. The rocks in this region are traversed by altered diabase dikes of various ages. Younger than these are auriferous quartz veins. Of the dikes mentioned, some are called "slate dikes." They are dike-formed masses consisting of a soft schist whose dominant components are chlorite and calcite or dolomite. These are considered altered diabase dikes. The diorite shows some interesting passages into schists. Along the boundary line between the diorite and the quartz-porphyry, the former becomes fissile. In approaching the boundary it is seen to contain chlorite laminæ which divide it into lenses. Closer to the boundary these increase in number, and the diorite becomes more and more slaty till it passes into a wholly chloritic schist.

The clay-slate, somewhat to the northwest of the granitoid rocks, on islands near the coast, is shown under the microscope, to be wholly crystalline, consisting of fine-grained quartz, feldspar and muscovite with occasional calcite, and sometimes graduating into muscovite schist.

On the eastern shore of the Bömmelö is a peculiar rock. It is a granular crystalline, gray granitic rock, stained with dark spots,

where biotite specially abounds. In the same mass are distinct rounded fragments of fine gray gneiss, feldspathic quartzite and white quartz. The fragments are often the size of a man's head and larger. The quartz fragments have sharp contours; those of feldspathic quartz are less distinct; while the gneiss fragments are welded into the surrounding rock, often appearing simply as dark patches. In the northern portions, the groundmass assumes a parallel structure, and gradually merges, by loss of fragments, into common granite. The author supposes that the rock was originally puddingstone, in which the fragments have mostly consisted of gneiss and granite. Those only have been left that contained most quartz; the rest have changed into a granitic mass.

A fine-grained diorite is described, interwoven with innumerable granite veins of various ages. The veins are so welded into the diorite that the whole assumes the appearance of a hornblende gneiss. In some places fragments of different mineralogical composition are enclosed, without order. The author suggests that a formation composed of different varieties of rock may have been broken to pieces, and these by motion in the fluid granitic mass, mingled together. Many examples are described of granites enclosing fragments of other rocks. A case is mentioned in which a mass of gneiss is changed by granite veins, into a breccia. The fragments are flattened as if by pressure. The rock is traversed by a schistose, fine crystalline dike consisting of hornblende, biotite, chlorite, with quartz as an interstitial filling. The schistosity runs parallel with the flattened fragments in the surrounding mass.

In some of the dioritic regions, the diorite is interwoven with innumerable granitic dikes and veins. Where the sides of the granite dikes can be seen, they are grooved in the direction of the stretching. The dikes in general, follow the foliation of the diorite, and they sometimes surpass in volume the dioritic rock. A person unacquainted with the general geological structure of the country might imagine veritable stratification.

In reference to the origin of some of the granitic rocks and other eruptives, Dr. Reusch says: "The quartz eye-gneiss of Karmöen and the granite of the Bömmelö contain interbedded masses of fragmental rocks merging into the surrounding massive rocks, and making it probable that the latter were also originally clastic, as before suggested in reference to some of the (Silurian) gneisses of the Bergen peninsula." He thinks the various non-gneissic masses included in the granites are the remains of rocks originally interbedded in the fragmental rocks from which the granite originated. Respecting gneissic masses included or interbedded, he is in doubt; but he inclines to think them structural varieties of the granite; since, for most of the comparatively massive gneiss-granite, it is difficult to assume another origin; as we find all transitions to varieties exhibiting quite characteristic granite structure. Nevertheless, we find central masses of granite undoubt-

edly eruptive, and ramifying into dikes and veins which pierce the surrounding terranes.

The tract under consideration where we observe the remarkable connection between a fragmental rock, a granite conglomerate and a true granite, must lead us to reflect, he says, on the origin of plutonic rocks in general. He holds that in some cases, originally sedimentary rocks may be regionally metamorphosed, and at last protruded as true eruptives. A. WINCHELL.

Ann Arbor, Oct. 10, 1889.

PERSONAL AND SCIENTIFIC NEWS.

PROF. F. H. SNOW HAS BEEN APPOINTED acting president of Kansas State University. Thus four of the western States have for presidents of their universities men whose professional training and labor had been scientific. Indiana has D. S. Jordan, an ichthyologist, Wisconsin has T. C. Chamberlin, a geologist, Iowa has C. A. Schaeffer, a chemist, and Kansas now has F. H. Snow, a geologist.

THE UNIVERSITY OF TEXAS, SCHOOL OF GEOLOGY, Austin, established and conducted by Prof. Robert T. Hill, exhibits a commendable appreciation of the sphere that such an organization should occupy, and, considering the great difficulties that environ such an enterprise in the newer institutions of learning, its activity and success are phenomenal. Its publications are of great value to Texas and to geology in general, and they manifest an energy and scientific skill that would be creditable to other and older institutions. It would be well if all state universities should maintain some similar agency for the publication of important scientific research. Particularly in western institutions are such auxiliaries needed. They have the material and the men to organize scientific bureaus, and they are beginning to realize the loss they are suffering by depending on the older institutions of the eastern States and on other means of publication.

THE LATE MEETING (FOR OCTOBER) OF THE MINNESOTA ACADEMY of Natural Sciences was the first held in the new building erected by the city of Minneapolis, known as the "City Library." The entire second floor of this building is to be occupied by the Academy. There was a large attendance. Papers were read by Prof. N. H. Winchell on *The so-called Huronian rocks in the vicinity of Sudbury, Canada*; by Mr. H. V. Winchell on *The iron-bearing formations of Minnesota*; by Prof. Chaney, of Northfield, on *Some remarkable forms supposed to be of Cryptozoon in the Shakopee limestone at Northfield;* and by Mr. Warren Upham on *A recent visit to Itasca lake.*

Yours truly
Geo. H. Cook.

THE

AMERICAN GEOLOGIST

VOL. IV. DECEMBER, 1889. No. 6.

GEORGE H. COOK, LATE STATE GEOLOGIST OF NEW JERSEY.

JOHN C. SMOCK.

Dr. George H. Cook, state geologist of New Jersey and vice president of Rutgers College, died at his residence in New Brunswick, N. J., Sunday, September 22, 1889.

This sudden death of one who was apparently in robust health and occupied with the responsible duties of directing a state geological survey and an agricultural experiment station, besides filling other positions of wide influence, has called out many expressions of a feeling of personal bereavement and of loss to the state and college which he served so long and so faithfully and to science in which he was an eminent leader. His efficient and successful management of the geological survey had gained for him a well earned and world-wide reputation and his amiable and generous nature and his unselfish devotion to science and to the highest interests of the people within the circle of his official influence, won for him a host of friends. As a teacher in the Rensselaer Polytechnic Institute, in the Albany Academy, and in Rutgers College he had given instruction in the natural sciences to a large number of pupils, many of whom now mourn their loss.

George Hammell Cook was born at Hanover, in Morris

county, New Jersey, January 5, 1818. His early education was obtained in the country school of his native town. After leaving school he was for a time engaged in surveying the line of the Morris and Essex railroad. In 1838 he entered the Rensselaer Polytechnic Institute at Troy, where he was graduated in 1839. In that institution he came under the instruction of Amos Eaton and acquired that love for the natural sciences with which that famous teacher inspired all who heard him. After graduation he was employed as tutor, then as adjunct professor, and from 1842 to 1846, as senior professor in the Institute. Removing to Albany he was engaged for a short time in business. In 1848 he entered the faculty of the Albany Academy as professor of mathematics and natural philosophy, and in 1851 was made principal, which place he filled until 1853 when he was called to the chair of chemistry and natural sciences in Rutgers College. He was elected vice president of the college in 1864, and in 1867 agriculture was added to his professorial work. The subsequent additional professorship in chemistry and geology relieved him of a part of his college duties, and from 1880 on he retained geology and agriculture. Rutgers Scientific School and the State College of Agriculture and the Mechanic Arts, established at New Brunswick, owe their existence and their prosperity largely to his earnest and persevering efforts in securing the congressional grant of public lands for the support of state colleges, and to his successful appeals for the legislative act in behalf of the Rutgers Scientific School. The education of the farmer and the promotion of agriculture were subjects of much thought and, after years of patient and unwearied effort, he rejoiced in the establishment of a state agricultural experiment station at New Brunswick and in connection with the state college. It was organized in 1880 with him as its director. His wise and economic administration brought increased appropriations and, in 1888, a special gift for the erection of a large and well planned building to be devoted to scientific investigations and experiments for the benefit of agriculture. No other state agricultural experiment station in our country has reached so large a part of the farming population of the state in which it is located. Its hold on the farmer is the evidence of the valuable work it has done for him.

Dr. Cook's official position in the geological survey of New

Jersey began in 1854, when he became associated with the late Dr. William Kitchell, state geologist. He was assistant geologist in charge of the southern division of the state for three years and made reports on the green-sand marl beds, on the clay beds, on the coast changes, and a final report on the county of Cape May. The most notable results of his survey were the discovery of a subsidence of the coast and the stratigraphical relations of the green-sand marl beds. A paper on the coast changes of level was read by him at the meeting of the American Association Adv. Sci. in Montreal in 1857. The relation of the several marl beds to one another and to the associated sand beds was worked out by him, and the stratigraphy was proven to be correct by the instrumental observations which he had made. Thus, almost at the outset of his long connection with the state survey, and his successful administration, he began the topographic work which has made that survey so useful to the people of New Jersey, and which upon its completion reflected so much credit and honor upon him. The structure of the whole southern part of the state was practically made out at that time. The studies of succeeding years have demonstrated the correctness of the stratigraphical order in the green-sand marl beds and added to the geological column the overlying and newer beds.

The geological survey was suspended from 1856 to 1863. The state legislature put the property of the survey in his care in 1863, and he made a report of his work to the State at the close of the season. The advantages of a geological survey and the desirability of completing it, moved the Legislature to order its resumption and he was made state geologist by an act of the Legislature passed in 1864. He held this position for a quarter of a century—and to his death. The results of the first quadrennial term were published in 1868 in the "Geology of New Jersey."[1] They were found to be of so much value to the people of the state that the survey was ordered to be continued a further term of four years. Supplementary acts passed by the Legislatures of 1872, 1876, 1880 and 1885 authorized the continuance of the survey. The almost unanimous votes in passing these acts show the confidence placed in him as the head of the survey; and the long official tenure

[1] "Geology of New Jersey," Newark, 1868, pp. xxiv and 900 with portfolio of maps.

of the office is unparalleled in the history of geological surveys in our country. The annual reports of the state geologist for the years 1869-1888 inclusive have given the records of the work done each succeeding year and represent the varied directions in which the investigations of the survey have been guided by him. In 1878 the report on the clay deposits of the state[2] appeared. The need of detailed topographic surveys as a basis for geological maps and their value in tracing out the stratigraphical relations within a small territory were shown in the map of the clay districts of Middlesex county, the first one of that series of the topographic department of the survey. The severe tests to which that map has been put and its tried value to the fire-clay and potter's-clay industries of the state constitute one of the most potent arguments for the usefulness of geological surveys and exhibit both the sagacity and the prudence of Dr. Cook in his direction of the survey.

The geological structure of the magnetic iron-ore beds in the northern part of the state, described in so clear and plain terms as to be of the greatest service to the iron miner and the iron-ore prospector, is another evidence of the practical direction of his investigations and of their service in developing the mineral resources of the state. These deposits were described by Prof. Rogers as veins and unstratified. The surveys of Dr. Cook showed them to be bedded members, in the crystalline rock series; and his later work indicated their occurrence in certain horizons in the Archæan group. To the geologist and to the mining engineer the full descriptions of the forms and location of these lenticular-shaped iron-ore beds are of the first importance, both in the study of the structure of the whole crystalline rock series and in the exploitation of the territory in search of additional ore supplies. The full and practical directions for the use of the magnetic compass in searching for ore and the magnetic survey of the state afford valuable data to the future explorer and suggest a more exhaustive survey in order to determine the horizon of the iron ores and their relation to the associated rocks.

Dr. Cook was one of the first to discover the existence of a great terminal moraine in the eastern United States, and his first public announcement of it was in a paper read at the

[2] Report on the Clay Deposits of Woodbridge, South Amboy and other places in New Jersey." Trenton, 1878, 8vo, VIII and 381 pp.

Wilkesbarre meeting of the American Institute of Mining Engineers, in May, 1877, "On the southern limit of the last glacial drift across New Jersey and the adjacent parts of New York and Pennsylvania." A description of this moraine appeared in his annual reports for the years 1877 and 1878. The clew to its existence was in the absence of the characteristic red sandstone and red shale in the stratified drift deposits in the southern central part of the state; and starting with this hint the southern limits of unsorted drift were followed eastward on Long Island and west of the Delaware to the Susquehanna. This study of glacial formations was fascinating and important, but the intense loyalty of the man to the practical interests of the people, for whom and by whom the survey was authorized, prevented him from following the subject where its application would have been of little real value, although it would have given him honor and gratified a natural thirst for additional knowledge.

The most conspicuous work of the geological survey was the production of the atlas of topographic maps. They are on a scale of one mile to the inch and show the configuration of the surface with accuracy and in much detail as to streams, roads, &c., and they are sought after by land surveyors, civil engineers, miners, and all who have occasion to examine the surface or study topography and geology. Geologists who have been obliged to use inaccurate maps can appreciate their value and give to Dr. Cook the credit of inaugurating the first accurate state topographic survey in connection with geological work in our country. And they will serve their highest scientific use in the revelations of structure yet to be read in these surface lines by the future student who may continue the survey of this best mapped state.

The practical direction of the survey was not confined to the above indicated channels, but flowed out wherever it could do service and minister to the people. The betterment of the soil, through the use of the natural fertilizer, the mapping of the forested areas and their description, the drainage of the swamp lands, the sources of abundant and wholesome supplies of water from artesian wells and from the natural reservoirs of the state, the climate and the whole physiography of the state were studied. His reports had the rare merit of plain, concise yet clear statements of facts which were understood

by those for whom they were written. And his conservatism kept him from hasty and glittering generalities and from the corrections and retractions incidental to undue haste and excessive personal ambition.

One volume of the final report had appeared and a second one was about ready to be sent to press at the time of his death. His plan contemplated its publication in four volumes, including a summary of the geology of the state and a report on the palæontology.

Dr. Cook was honored by membership in many societies. At the Cleveland meeting of the American Association he gave the vice-presidential address in Section E. In 1887 he was elected a member of the National Academy of Science. Of the International Geological Congress he was an active member and the reporter of the Mesozoic. From the University of New York he had received the degree of Ph. D. as early as 1856, and Union College had honored him with that of doctor of laws.

A friend whose devotion never wavered, a loyal citizen, ready for every duty, a true scientist and a manly Christian, he has left an example for us, if we would make the world better and wiser.

THE CINCINNATI ROCKS: WHAT HAS BEEN THEIR PHYSICAL HISTORY?

By Nelson W. Perry.

The group of rocks forming the upper portion of the Lower Silurian, and more specifically known as the "Cincinnati group," has been for many years one of the most interesting to the palæontologist and geologist. The great abundance and variety of its fossils have attracted the attention and study of specialists in all parts of the world, and the result is that its life history is now pretty well understood. The physical history of this group, however, has been but little studied, and even to-day we find but little in literature bearing on this subject.

The problems presented are of a peculiar nature and seem not to be duplicated in any other of the great geological epochs—certainly not on such a grand scale. This fact has not until recently been duly recognized. The phenomena

observed have been duly explained by theories some of which it seems to the writer are not at all applicable.

It is the object of this paper to present some of the physical peculiarities of the Cincinnati group and to draw from them some conclusions to which they seem to point.

It seems to me that the greatest obstacle to a right understanding of the method of deposition of these rocks has been an almost universal belief in the rule that limestones are of deep-sea origin. To one wedded to a belief in the universality of this law, a fossil, however significant it might be of shallow water conditions, if found in sandstone or shale, loses its significance if found in limestone. "Limestone is a deep-sea deposit, ergo shallow water indications in limestones are impossible. Whatever in limestone is found that resembles these must be accounted for in other ways."

Increased study of these rocks has brought to light many facts not accessible to the earlier writers, and has thrown such additional light on the subject as to necessitate the rejection of some of the earlier conclusions.

We will cite the occurrence at numerous horizons of a wavelike structure of the limestone. This is a marked feature from the Point Pleasant beds to the very top of the Cincinnati rocks, and has attracted the attention of all students of this series. These were not thought to be the result of wave action, because they were chiefly found in limestone, and limestone being a deep-sea deposit was beyond the reach of such agencies.

Speaking of this wavelike structure, Prof. Orton says:[1] "This peculiar structure was noticed by him (Dr. Locke) in the upper beds of the formation, but it is an even more striking characteristic of the rock in its lower beds as shown in the river quarries of Cincinnati or in the lowermost 100 feet that are there exposed. * * The waved layers are overlain by shale in every instance. Dr. Locke's explanation of these facts, involving a fluid state of the carbonate of lime and sheets of shale falling in 'vertical strata' through the deep seas, seems entirely inadmissable."

"The only other explanation thus far proffered (1873) is that suggested by the name, viz.: that the floor of the Cincinnati sea was acted on from time to time by waves or similar movements of the ocean waters. In opposition to this view

[1] Geological survey of Ohio, vol. 1, p. 377.

it may be said: 1st, that there are many reasons for believing that the Cincinnati rocks grew upon the floor of a *deep sea** far below the action of surface waves; and 2nd, that the *limestone layers alone** being thus shaped, is sufficient to set aside the explanation.

"If these inequalities of surface are due to wave action of any sort, it is impossible to see why the action should be *limited entirely to the finest limestone beds** of the series while the soft shales which could so *easily register** any movement of the waters *never** exhibit the slightest indication of such agencies.

"While both of these modes of accounting for the facts are rejected as entirely untrustworthy, nothing in the way of explanation will be offered here, but the suggestion that the facts seem to point to a *concretionary action* as the force to which we must look."

I have quoted Prof. Orton thus fully to show the opinion prevailing, as well as his own, at the time the report was published (1873)—opinions evidently formed under the impression that limestones must be of deep-sea origin.

Dr. Newberry, however, with that keen sagacity in the interpretation of geological phenomena for which he is so widely known, differed most radically from the generally accepted views.[2] "The earthy limestones of the Hudson period indicate a shallowing and retreating sea—an approach to land conditions, and the completion of one cycle of deposition."

Interspersed among the strata are found, besides those composed of fine-grained compact limestones, others that are made up almost entirely of fossil remains—sometimes fairly cemented together, at others scarcely at all, so that on the slightest exposure to the weather they disintegrate and crumble apart. In such strata an unbroken or nearly perfect fossil is rarely found. In other places strata of considerable thickness are found, largely composed of the valves of Strophomena, etc., lying up against each other at an angle to the plane of stratification and almost devoid of cementing material. There are still others, usually of an earthy character, that are full of peculiar markings that have been variously

* Italics are mine.—N. W. P.

* Italics are mine and will be referred to further on.

2 Geological survey of Ohio, vol. I, p. 61.

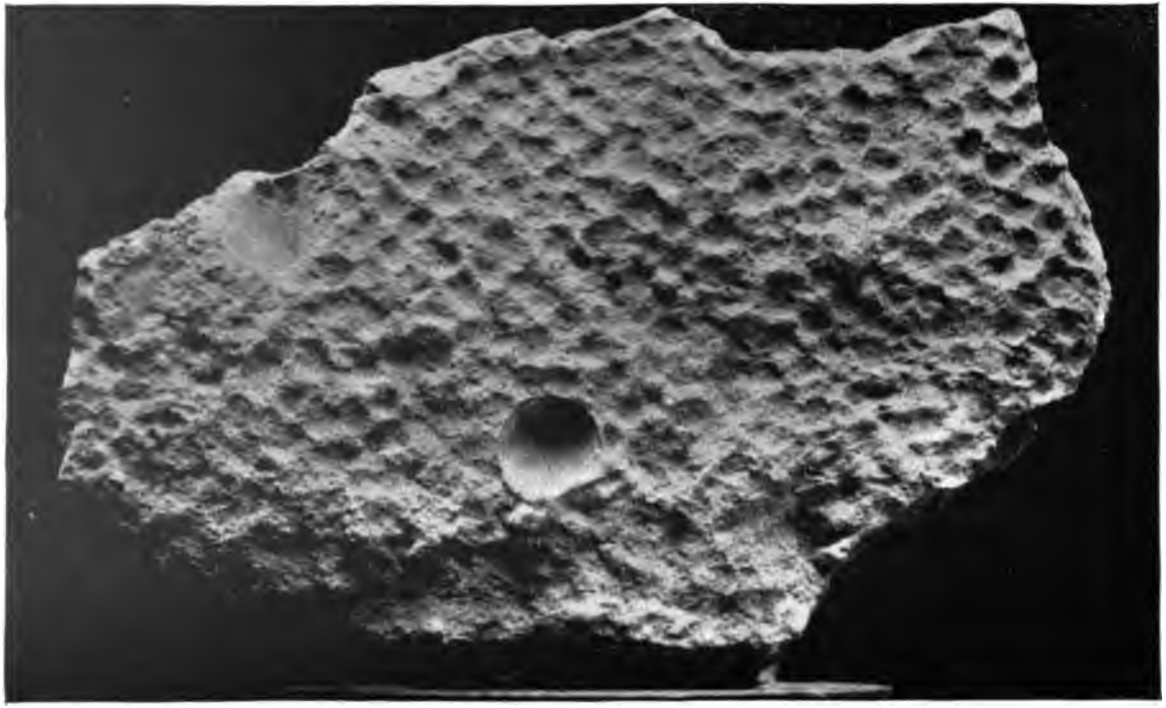

FIG. 1—RAIN DROP IMPRESSIONS IN AVERAGE GRADE LIMESTONE. ACTUAL SIZE 14¾ IN. BY 9¾ INCHES. SMILEY'S DAM, FOUR MILE CREEK, NEAR OXFORD, OHIO.

interpreted as trails of annelids, mollusks, etc., and the impressions of fucoids. Still further examination has disclosed markings such as might be made by trickling water, others that look like mudcracks, and so on.

These have been more particularly noticed in the vicinity of the wave-mark horizons, and have led Shaler of Kentucky, and Prof. Jos. F. James, to the conclusion that they indicate ancient beach-marks. The latter, in a paper which appeared in "Science," March 20, 1885, vol. v. p. 231 et seq., speaks of all of these, and concludes that there are at least two well defined beaches and probably others not yet discovered. To account for these he assumes as many alternate upheavals and depressions of the ancient sea bottom, but says nothing to imply that he does not believe the general condition of the sea to have been a deep one. To substantiate his opinion of the littoral character of these two or more horizons, he gathers together many evidences not before published, I believe, and sustains his argument in a masterly and convincing manner.

My own attention was especially called to the study of the physical history of these rocks three summers ago when I found in an exposure on the Four Mile creek, near Oxford, Butler county, O., a slab about fourteen inches in length by nine inches broad, beautifully covered on one side with unmistakable rain-drop impressions. (Fig. 1) This slab was of limestone of the average grade of purity found throughout the Cincinnati group, and was an exceedingly interesting specimen. Both above it and below it were strata bearing the "dumb-bell" fossil, and filled with trails and other markings, all of which seemed indicative of littoral conditions. But to make the conclusion positive it seemed necessary that other concurrent testimony be adduced, such as wave-marks, rill-marks, mudcracks, etc., and I have devoted myself at intervals ever since to collecting such evidence.

Dr. F. W. McFarland, then president of Miami University, upon seeing the specimen, at once recognized its value and importance, and most kindly volunteered to run a line of levels from some established bench-mark to the horizon from whence the rock came. Previous to this the village of Oxford had sunk an unsuccessful gas-well near the C. H. & I. depot which had given us a complete geological section from near

the top of the Cincinnati series down into the Calciferous sandrock. Choosing the railroad levels at the depot as his bench-mark he and his class in engineering ran a line of levels to the spot where the stone was found—a distance of about five miles—and we were thus enabled to locate the horizon with great exactness and found it to be within a few inches of 600 feet above the top of the Trenton limestone. In this estimate the 50 feet of dark shaly stone found in the gas-well section, supposed to be the equivalent to the Pt. Pleasant beds, were regarded as not belonging to the Trenton and are included in the figures mentioned.

Frequent visits to this locality, known as "Smiley's Dam," have always resulted in finding other specimens of raindrop impressions.

Some time later, having interested Mr. David McCord of Oxford in my work, we visited together a locality known as "Little Four Mile." The stream was perfectly dry, affording an excellent opportunity of examining its bed. At a place known as Ridenour's Mills the bed consisted of a succession of large stony floors—often fifty feet square or more—composed of successive strata of compact limestone. Going up stream from Ridenour's Mills we found almost every stratum distinctly wave-marked. The waves were of all sizes from what would correspond with the gentle roll of the sea, indicating comparatively deep water, and having their ridges many feet apart, down to the tiniest little ripple-marks that could only have been formed in the shallowest and most circumscribed pools. These wave-marks differed in direction in different strata, but were, with the exception to be noted, all in very pure limestone. Some of the strata were composed of the very finest and homogeneous material of a deep blue color, while others, equally hard and compact perhaps, were made up of crinoidal and shell-fragments—the limestone sand of a former beach. Here as elsewhere throughout the Cincinnati group the limestones alternate with strata of shale. I was much interested in finding in this *shale* also distinct ripple-marks. I have a photograph made by Mr. William McCord from specimens collected by his father, Mr. David McCord, on this same trip, which represents the ripples about three-quarters their natural size.(Fig.2)I think no one can look upon these and other similar specimens collected and doubt their origin.

I have found equally good ripple marks in the shale at other horizons, but perfect as these are they are scarcely more so than those found in the limestone strata at a dozen or more horizons exposed in the bed of this same creek. I know of no locality where the evidence of former wave action can be studied, on so large a scale and to such good advantage, as in the bed of this creek when it is dry. In making such a study one also becomes familiar with many other indications of shallow water deposition, which if seen alone would not warrant this interpretation, but associated as they are, seem to permit of no other construction. These have been invaluable to me in my later work, but while I can not regard them when alone as positive evidence, yet they are presumptive proof which amounts almost to certainty when two or more are found together.

Prof. C. W. Hargitt, having been appointed to the chair of Geology and Biology at Miami University, becoming acquainted with the work I was engaged in, became quite interested and visited with me many o the localities where exposures of especial interest were to be found. I had not yet found mud-cracks, but he had, and at my request sent for a photograph of the same. He also kindly wrote a description of the specimen which I quote in full.

"A rock measuring 17x26 inches (approximately) was obtained from the Lower Silurian of Dearborn county, Indiana, at about 600 feet above the base of the Cincinnati group, as estimated from the surveys of the O. & M. R. R., and from measurements taken from the Lawrenceburgh gas-wells, thus making the horizon at which these evidences are very marked about the same as that of the raindrop impressions, etc. This slab (mud-cracks) is now in the museum of Moore's Hill College, Indiana, where it can be seen at any time. By chemical tests it proved to be a good quality of limestone, as is much of that found in the same region." (Fig. 3)

Referring to the italicized portions of the quotation from Prof. Orton, which express reasons why some of these phenomena are not what they seem to be—Prof. Orton says that "the *limestone layers alone* being thus shaped is sufficient to set aside the explanation," viz.: that the wave-like structure was due to wave action. We have found that the ripple or wave-marks are *not* confined to the limestone strata; we have found several horizons where they occur in shale.

He also says: "If these inequalities of surface are due to wave action of any sort, it is impossible to see why the action should be *limited entirely* to the finest limestone beds of the series, while the soft shales which could so *easily register* any movement of the waters *never* exhibit the slightest indications of such agencies."

The wave-marks at Ludlow, Ky., which have crests some six or seven inches high and whose distance apart is three or more feet, are in limestone *not* of the finest structure, but on the contrary of *very* coarse structure. They are almost wholly made up of the fragments of crinoid stems and other equally coarse debris. This is also the case in many other localities visited where waves of similar size were found, though they do also occur in the finer limestones, as in some of the horizons in the Little Four Mile creek.

His statement that the soft shales "could so easily register any of the movements of the water" does not seem to me to be in accordance with good reasoning. It would seem rather that they could register the movements of the water only in exceptional cases, such as in very small and shallow pools where the agitation of the water could not become sufficient to keep the very light earthy matter in suspension. Where the waves were larger this material (the shale) would if previously deposited be taken into suspension by the agitation of the water, and if in suspension would remain so until the movement of the water completely subsided when it would be slowly deposited in a regular layer, covering up the heavier limestone which had kept a record of the movement. Such would seem more plausible and entirely in accordance with the facts as we have found them. In the shales such markings could only be made and preserved under a concurrence of exceptional circumstances, and I therefore look upon their discovery as a fortunate and important one, instead of one to be expected.

His suggestion that *concretionary action* was probably the cause of these so-called wave-marks, must, I think, from the evidence of the waves themselves, fall to the ground.

While some of these markings are found in a very fine-grained and homogeneous limestone under conditions where concretionary action *might* be looked for, yet the majority,

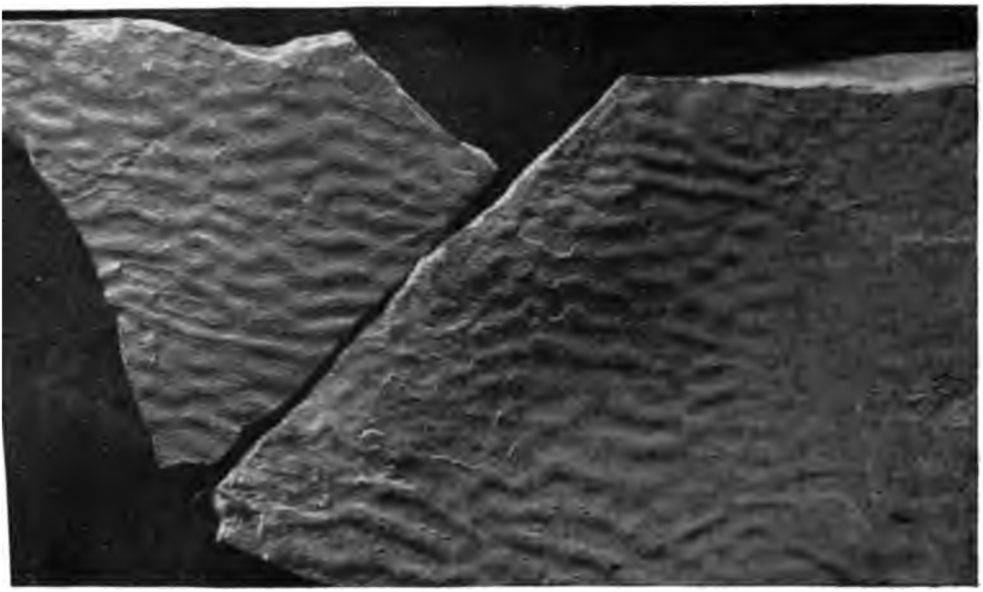

FIG. 2—RIPPLE MARKS IN SHALE; THREE-FOURTHS NATURAL SIZE
LITTLE FOUR MILE CREEK, NEAR OXFORD, OHIO.

FIG. 3—MUD CRACKS ON LIMESTONE,
NEAR MOORE'S HILL, INDIANA.

especially of the larger waves observed, are in limestone composed of coarse well defined fragments in which such action would not be possible. We also find that where the waves occur in the finer grained limestone the stratification remains quite as distinct as in similar strata not thus marked. Had concretionary action taken place these lines must necessarily have been obliterated. This may be sufficient, but fortunately much other evidence is at hand to show that at times, at least, the sea was shallow.

A more extended study of the river quarries near Cincinnati, with but few breaks up to the outliers of the Clinton limestone in Preble county, has shown a great number of horizons that bear evidence of shallow water conditions. If, therefore, we accept Prof. Shaler's and Prof. James' theory that each beach-mark represents a period of elevation succeeded by one of depression, we must believe in such frequent recurrence of these movements that there should certainly be left some evidence of them in the strata, such as faults, metamorphism, etc. These have not been observed as far as we know, and it appears to the writer that such a theory is entirely unnecessary and has been promulgated because of the difficulty to completely break away from the old assumption that limestone is necessarily the product of a deep sea. It would appear that the only foundation for such a theory is the fact that above each of these "beach-marks" pure limestone strata are found.

The most striking feature of the Cincinnati series from its base to its top, is the very regular alternation of strata of limestone and shale. Each stratum is sharply defined—there is no gradual merging of one into the other. Each limestone stratum is nearly pure carbonate of lime and magnesia and is succeeded by a stratum, calcareous to be sure, but as different from the former, and the plane of conformity as distinctly and as sharply marked, as though the conditions of deposition were not only entirely different, but were instantly, not gradually, changed. With the older idea of deep-sea origin of the limestone and a shallow-sea origin for the shales, we would have to assume a long and regularly recurring series of cataclysms to account for the structure observed. Such a theory is so at variance with geological concepts that I am not aware of its ever having been soberly advanced. Hardly less

absurd is the statement that "the shale is undoubtedly due to the wash of the shores brought there by the moving waters." When we remember that Cincinnati, where this peculiar structure is observed in all its perfection, was hundreds of miles from the nearest shore line, we see the difficulty in the way of this theory. It is also insufficient on other grounds, for if it came from any such source and was gradually deposited, we should have instead of the pure limestones with sharp definition, strata varying in composition from nearly pure carbonate of lime, and passing through all degrees of mixture until the purest shale was reached and vice versa.

Analyses show that at Waynesville, a sample of the limestone contained 96.56% of the carbonates of lime and magnesia, whereas analyses[3] of shales from the same locality give the following result:

	Waynesville.	*Sycamore Hill.*
Siliceous matter	69.90	81.50
Alumina and iron	10.24	9.00
Carb. lime and magnesia	14.46	6.04
Potash and soda	5.40	
Phosphoric acid	0.16	

We think both of these theories are untenable and unworthy even of second thought. We believe that any theory that does not account for the synchronous deposit of both will fail to answer all the conditions of the case. We believe that the limestone and the shale must have originated at or near where they are found to-day, and it is as reasonable to claim a foreign origin for one as for the other. The assumption of a shallow water origin for one, therefore, involves a like origin for the other. If we assume a condition of shallow water extending throughout the Cincinnati epoch, and the bed of that shallow sea to have been inhabited by a dense animal life as we know it to have been, and also assume a luxuriant flora at the same time we have all the conditions on which to base an explanation of these alternating strata of shale and limestone. The animal life obtained its lime from the water in which it lived and the plant life obtained its mineral matter from the same source. The dead shells, through constant attrition and grinding, were partly reduced to the finest powder and held in suspension by the agitated water, until,

[3] Wormley.

through transportation to quieter parts, they were allowed to settle. The mineral constituents of the decayed plants had a somewhat similar history, though being in an almost inpalpable form would remain in suspension longer. If this were true and *all* that occurred, we should find the lower portion of each stratum of stone nearly pure carbonates of lime and magnesia, but gradually merging into a nearly pure shale at the top. But we have assumed a shallow sea, whose bottom was scarcely ever free from the jigging action of surface waves. This action would gradually sort the constituents of the last-deposited stratum according to size and specific gravity. This stratum would eventually be sharply divided into two—according to the character of its constituents—the bottom layer being composed of mechanically triturated fragments of shells.

This theory does not imply a limited or definite time for the formation of the two strata, for after being once deposited they may both have been many times taken into suspension partially, at least, by more violent disturbances of the water, and again deposited. Each repetition of this redeposition would tend to mark more sharply the line between the two. Finely ground limestone suspended in water tends upon settling to become quite compact. The writer has experimented on this and has obtained a firmer mass by the mere action of gravity than he could obtain by compressing the same material by hydraulic power under a pressure of five tons to the square inch.

We may suppose that the purer limestone, separated out as above, may have formed a stratum unacted upon by the gentler movements of the water, while the overlying shale was still being kept in motion. In this way the limestone stratum might continue to increase in thickness for long periods of time, retaining its great purity and always leaving a well defined surface upon which the overlying shale might be compacted when a favorable opportunity, long enough continued, should arise.

This shale, should it be allowed to settle thoroughly and remain sufficiently long in this condition, might become coherent enough to resist the further jigging action of the water. A new deposition would now commence and after passing through the same stages we should have two more strata—one of limestone and the other of shale.

This does away entirely with the deep-sea idea. It also does away with the transportation theory to account for the shale, which seems under the circumstances to be not at all borne out by the observed facts. It, however, assumes a shallow sea, even at times extending to land conditions. This sea must have been in nearly all parts shallow enough to be affected at its bottom by surface waves, and in many cases shallow enough to leave the imprint of these waves in characters so strong as not to be easily misunderstood.

That the constituents of the strata must have been originally derived from the land, is undoubtedly true, but they came in the form of solutions, and not, as some have supposed, in finely divided particles transported by streams.

The necessity of numerous alternate upheavals and depressions of the forming continent is no longer apparent, but another factor seems demanded, viz: a gradual sinking of the area during this period. My own idea is that this sinking about kept pace with the upward growth of the strata, so that, except in a few instances which might be cited, the generally shallow character of the water was not much changed until near the end when the great upheaval that gave rise to the Cincinnati axis put a stop to further aqueous growth and changed the condition from—shall I say an amphibious to one of dry land?

If this reasoning be correct, every stratum of limestone, with its accompanying shale constitutes indubitable proof of a shallow sea. How deep this sea may have been in its deepest portions it is impossible to tell, but as I am told by old lake Erie pilots that after storms on the lake the whole sheet of water becomes muddy, we may conclude that portions of the Cincinnati sea may have been at least as deep as lake Erie.

Cincinnati, *Aug. 19th*, *1889.*

The Spanish term *adobe* has been adopted by I. C. Russell as a scientific designation for the peculiar superficial calcareous clay, or loess, that is generally distributed in the valleys of the "arid regions." It is extensively used by the Indians and the Mexicans in making sun-dried brick.—*Geol. Mag. July*, *1889*, *p. 291.*

ON SOME PALÆOZOIC OSTRACODA FROM PENNSYLVANIA, U. S.

By PROFESSOR T. RUPERT JONES,
F. R. S., F. G. S., Corresp. Memb. Acad. Nat. Sci., Philadelphia, &c., &c.

[With Plate*].

A collection of Palæozoic Ostracoda, collected by Prof. E. W. Claypole, F.G.S., of Buchtel College, Akron, Ohio, during his work on the Geological Survey of Pennsylvania, having been sent to me by him for examination, the present notes and plate are supplied for their identification.

CONTENTS.

I. DEVONIAN SPECIES. Figs. 1, 2, 10-15.

1. PRIMITIA MUNDULA Jones.

Some of the soft, brownish, mottled, argillaceous limestone of the Upper-Devonian Chemung-Catskill shales at King's Mill, Perry county, Pennsylvania, abounds with *Primitia mundula*, varying in size, and more or less in outline, and in the proportions of the sulcus. Some are only .75mm., or less, in length; the largest are 1.25mm. long and beautifully reticulate. These closely resemble some from the Lower-Devonian strata of New Brunswick,[1] but are rather longer in proportion to the hight. In a letter Prof. E. W. Claypole refers to this rock as a rough, rudely stratified shale, with the Entomostraca (*Primitiæ*) in little nests between irregular layers of the shale.

"With these *Primitiæ* here and there occur some small white bivalve shells, mostly subtriangular, and all bearing concentric ridges, rather wide apart. They are mostly smooth, but some show traces of delicate reticulation. Hence there is some resemblance to *Estheria*, but there appear to be more than one kind, and several have a strong vertical depression or sulcus just below the umbo. Their alliances are obscure.

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* This plate was drawn with the aid of a grant from the Royal Society of London.

[1] Such as figs. 1 and 2, a. b. pl. 16, "Ann. Mag. Nat. Hist." Ser. 6, vol. III, 1889, p. 375, &c.

2. KLŒDENIA SIMPLEX. Sp. nov. Fig. 14.

This small subquadrate valve, represented by a cast only, has at first sight the look of a *Primitia*, but the characteristic sulcus is wanting, and an isolated tubercle or minute lobe occupies its place. Possibly this may be a young individual of either a *Klœdenia* or a *Beyrichia*. The Beyrichian lobes and sulci are not developed; and it may be possible that the little lobe is that of a *Klœdenia*, very near the dorsal margin, but more than usually isolated. The nearest published form is one of the Acadian specimens of *Beyrichia klœdeni*, var. *acadica* Jones. "Ann. Mag. Nat. Hist." ser. 6, vol. III (1889) p. 380, pl. 17, fig. 4; but the individual under notice has, I think, a closer alliance with *Klœdenia* than with *Beyrichia*, the little subcentral lobe being nearer to the dorsal margin, and the other lobes less developed, than in the Acadian specimen. *Kl. simplex* is in the dark mottled limestone from the Limestone-shales of the Chemung-Catskill beds (Upper Devonian of the U. S.), at King's Mill, Perry county, Pennsylvania.

3. BYTHOCYPRIS FAVULOSA. Figs. 1 and 2, a. b. c.

These small specimens are only casts, and are doubtfully referred to *Bythocypris*, as the genus most convenient to receive them according to their subovate-oblong shape.[2] The hollow cast, fig. 2a, and another similar but imperfect cast show a coarsely reticulate or honeycomb-like structure (figs. 2b, 2c), which holds the place of the external surface of the valve. This is not an unusual ornament of some ostracodous valves; but it is here very coarse in proportion to the area of the valve, and it is unusual in such simple cypridiform species as the *Bythocypris*, &c. One specimen is about 1 mm., and the other a little more in length. From buff-colored non-calcareous shale of the Marcellus limestone,[3] Perry county, Pa., near New Bloomfield.

4. BOLLIA UNGULA (Claypole MS.) Figs. 10-13.

For notes on the genus *Bollia*, see "Ann. Mag. Nat. Hist." ser. 5, vol. XVII (1886), pp. 360 and 406. Prof. Claypole's specimens are well preserved casts in buff-colored, non-calcareous

[2] For some other Palæozoic Ostracodes referable to this genus, see the "Annals and Mag. Nat. Hist." ser. 5, vol. XVIII (1886), pp. 250, &c.; and vol. XIX (1887), pp. 184, &c.

[3] In the Hamilton group of the Upper Helderberg (Middle Devonian of the U. S).

shales from the Marcellus limestone of Perry county, Pennsylvania (near New Bloomfield). There are several, and they vary from 1 to 2½ mm. in length. The proportions of some of the best are given in the figures 10-13, magnified fifteen diameters. In some respects they resemble *Bollia lata* Hall;[4] but they are larger, and the central curved ridge is much thinner at its curve, whereas in the specimens from New York state the curve is thicker just there, and is not so symmetrical throughout as in the Pennsylvania specimens. Hence I prefer to regard the latter as specifically distinct, and to adopt Prof. Claypole's MS. specific name (having reference to the *hoof-like* ridge), than to refer them to *Bollia lata*. A hollow cast of the outside, and one presumably perfect valve give evidence of a smooth exterior.

The slight variations in the shape and proportions of the curved subcentral ridge and of the marginal ridge are well shown in the figures 10-13.

5. **PRIMITIA PENNSYLVANICA.** Sp. nov. Figs. 15a, 15b.

Another small ostracod, 1 mm, occurs in the buff-shale of the Marcellus limestone, from Perry county, Pa. Related to *Primitia mundula* Jones, ("Ann. Mag. Nat. Hist." ser. 2. vol. XVI (1855), p. 174, pl. 6, figs. 28 to 31), it is, however, much more oval than any there figured. The dorsal is even more arched than the ventral margin, and curves downwards anteriorly more rapidly than it does behind. The sulcus, well defined, and bordered on each side by a distinct swelling, is much nearer to one end than the other of the valve, not quite at its highest convexity, but very near the greatest curve of the dorsal edge.

Note on a specimen of oölitic limestone from the Marcellus series Perry county, Pa., which accompanied the foregoing specimens. By EDWARD WETHERED, Esq., F.G.S., F.C.S., &c., &c.

When seen as a hand specimen, this rock promised well for an interesting microscopic slide. Oölitic granules were clearly defined; but the anticipations as to well preserved structure were not realized. The rock was soft to grind, and a certain amount of cleavage was apparent. The sections showed the oölitic granules in an argillaceous matrix, with very minute grains of detrital material. The granules showed the usual concentric structure, but there was an absence of a nucleus, which in the British Jurassic oölites and Carboniferous oölitic limestone is a feature. The granules are ferruginous; I rather suspect,

[4] Palæontology of New York, vol. II, 1852, p. 301, pl. A 66, figs. 10a, b, d (not figs. c and e), also some in the British museum. I may here mention that I have to refer *lata* and *symmetrica* to *Bollia*, and *spinosa* to *Æchmina*.

however, that they were not originally so, but that the oxide of iron has replaced the original carbonate of lime. In short, my impression is that the rock was once a calcareous oölite, but in the course of time has been altered by pressure and chemical changes. In this way the original structure of the granules has been modified, and their nuclei have disappeared. When tested with hydrochloric acid, considerable effervescence takes place, due to the presence of carbonate of lime; but the rock as a limestone is impure.

II. SILURIAN SPECIES. Figs. 3-9.

1. BYTHOCYPRIS OVIFORMIS. Sp. nov. Figs. 3a-3c.

Carapace, very small, about .66 mm. long, almost egg-shaped, but unequally convex on the upper and lower margins, and too much narrowed and compressed anteriorly to be truly ovate. The left valve is by far the larger, as in *Bythocypris;* and the dorsal edge of the left valve is much thickened in the middle, where it strongly overlaps the other valve. The surface is minutely punctate. Another, rather smaller, specimen (imperfect) occurs with the same superficial ornament.

From the dark-colored Lewistown shaly limestone of the Lower Heldeberg group, Perry county Pa., and probably equivalent to the "Ludlow" beds of England.

2. LEPERDITIA SUBQUADRATA. Sp. nov. Figs. 4a-4d.

This very small carapace, subquadrate in outline, and moderately convex, shows the ventral overlap distinctive of *Leperditia*. In outline and contour it somewhat resembles *L. nana* Jones, ("Ann. Mag. N. H." ser. 3, vol. I (1858), p. 244, pl. 9, fig. 12; *L. canadensis*, var. *nana*, *op. cit.* 1881, p. 343); but its ends are more semicircular. In Dr. James Hall's *Lep.* (*Isochilina*) *minutissma*, "24th Report State Cabinet, N. Y." 1872, p. 231, pl. 8, fig. 13, and "Geol. Survey Ohio," vol. II, part 2 (1875), p. 102, pl. 4. fig. 4, the ends are unequal; his *L. hudsonica* is like it in outline, but is larger and much more convex. Another little *Leperditia* (*L. ovata* Jones "Ann. Mag. N. H." ser. 3, vol. I, 1858,[5] p. 252, pl. 10. fig. 14) is known from Pennsylvania. It is from a lower horizon and is more ovate and convex. The shape of the Carboniferous *L. scotoburdigalensis* (probably a dwarf form of *L. okeni*) also approaches that of the specimen under notice, but it is

[5] Alluding to this paper and plate, I may mention that figs. 15, 16, 17 and 18 are all *Beyrichia pennsylvanica;* but figs. 16, 17 and 18 are destitute of the marginal fringe, which, present in fig. 15, led to the mistake of the figure being referred to *B. maccoyiana*. See also "Ann. M. N. H." ser. 5, vol. XVII (1886), p. 347, *note*.

larger, more convex, and usually bears either the muscle-spot or the eye-tubercle.

Only two specimens of *L. subquadrata* have been noticed. They are from .75 to 1 mm. in length. From the before mentioned dark-gray Lower Helderberg limestone of Perry county, Pennsylvania.

3. KLŒDENIA PENNSYLVANICA. Sp. nov. Figs. 5-9.

Numerous specimens of a *Klœdenia,* near to *Kl. notata* (Hall), occur in the dark-colored Lower Helderberg limestone from Perry county, Pa. They vary from about 1 to 2 mm. in length. Prof. Claypole referred them to Dr. James Hall's *Beyrichia notata,* but I find from good typical specimens of this species that its valves are larger, and more nearly approach those of *Klœdenia wilckensiana,* though the lobes and sulci are not so strongly pronounced as in the latter.

In the Pennsylvanian species the middle lobe is narrowed by its two, short, strong, parallel, lateral sulci; herein differing from both of the other species alluded to.

The figures exhibit the chief variations in outline and proportions of parts. In figs. 7a and 9 we see a faint sulcation of the hinder lobe, analogous to the posterior furrow in figs. 17, 18 and 19, of plate 5, "Ann. Mag. Nat. Hist." ser. 2, vol. XVI (1855). This feature is strongly emphasized in *Kl. plicata* Jones *op. cit.* figs 20, 21; and *op. cit.* ser. 5, vol. XVII (1886), pp. 347 and 362; and ser. 6, vol. I (1888), p. 398. A faint indication of a delicate reticulation is observable on the surface of some specimens.

EXPLANATION OF PLATE.

Fig. 1. *Bythocypris favulosa,* sp. nov. Cast of the inside of a right valve; x 15 diam.

2. *B. favulosa,* sp. nov. *a,* hollow cast of the outside of right valve; x 15 diam.; *b,* appearance of the inside of the hollow cast, x 40 diam.; *c,* reversed drawing of 2*b,* showing it as the original reticulation; x 40 diam.

3. *B. oviformis,* sp. nov. Complete carapace. *a,* showing the right valve and edges of the left valve; *b,* showing the left valve; *c,* the dorsal aspect; *d,* posterior aspect; all magnified 40 diam.; *e,* outline of the carapace, x 15 diam.

4. *Leperditia subquadrata,* sp. nov. Complete carapace. *a,* showing the left valve; *b,* dorsal aspect; *c,* posterior aspect; all x 40 diam.; *d,* outline of carapace, x 15 diam.

5-9. *Klœdenia pennsylvanica* sp. nov. All magnified 15 diam. 5*a,* complete carapace, with the left valve outwards; 5*b,* right valve; 5*c,* ventral aspect; 5*d,* end view; 6, left valve; 7*a,* carapace showing the right valve and the edges of the other; 7*b,* ventral aspect; 8, a large

left valve; 9, a left valve, showing (like fig. 9) a faint oblique sulcus on the posterior lobe.

10-13. *Bollia ungula* (Claypole MS.) Internal casts. Magn. 15 diam.

14. *Klœdenia simplex*, sp. nov. Internal cast of right valve. x 15 diam.

15. *Primitia pennsylvanica*, sp. nov. *a*, internal cast of a left valve; *b*, edge view; x 15 diam.

Fig. 14 is from the mottled Devonian limestone shale at King's Mill, Perry county, Pa.

Figs. 1, 2, 10, 11, 12, 13 and 15 are from the buff shale of the Marcellus limestone of Perry county, Pa.

Figs. 3, 4, 5, 6, 7, 8 and 9 are from the dark-gray Lower Helderberg limestone of Perry county, Pa.

METHODS OF STRATIGRAPHY IN STUDYING THE HURONIAN.

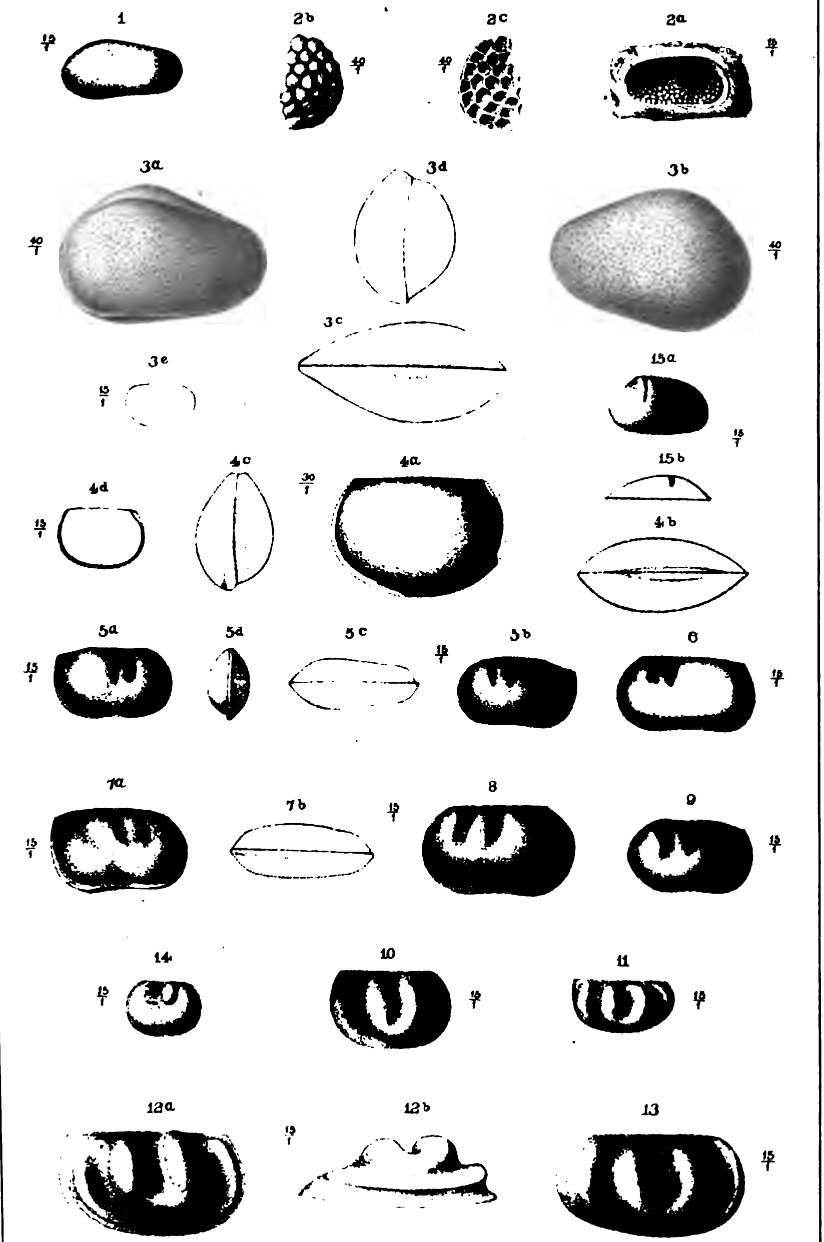
Written for the Madison meeting of the Western Society of Naturalists, Oct. 24, 1889.

N. H. WINCHELL.

CONTENTS.

Recent work in the Archæan rocks in the Northwest has shown that the Huronian system has been variously understood by geologists working in the different states and in the Dominion of Canada. This difference of understanding concerning an important series of strata of the earth's crust, resulting in differences of nomenclature, prompts me to offer to the Society some remarks on the methods pursued by the different investigators, and a comparison of them and their results with the methods and results arrived at by more recent research.

What is the Huronian? It will be in accordance with the equities of scientific nomenclature to accept the definition of the Huronian as given by the originators of the name as they finally left it. It was first named by Sir Wm. Logan and Dr. T. Sterry Hunt jointly, in a small pamphlet published in



Geo West & Sons del lith et imp.

OSTRACODA FROM PENNSYLVANIA.

French at Paris in 1855.[1] This was thirteen years after the geological survey of Canada was begun, and one year later than the use of the term by Mr. Murray, although Mr. Murray's reports in which the term was first used were not offered for publication by Mr. Logan till two years after the publication of the French document.[2] It is evident, however, by an examination of this French document and of some of Dr. Hunt's later references to the Huronian system[3] that the authors of the term intended only to apply an American designation to what had been styled Lower Cambrian in Europe, —i. e., to designate a formation intervening between the Silurian (as claimed by Murchison) and the fundamental gneiss, or Laurentian. Such rocks had been examined on the north shore of lake Superior by Mr. Logan in 1846 and on lake Huron in 1848, and by Mr. Murray in 1849 on the north shore of lake Huron. So far as possible to understand the descriptions of Logan and Hunt, and of Logan and Murray, whether we examine their sections in the geological reports of Canada, or their general statements in the French document, or even the later descriptions and discussions of Dr. Hunt, the original idea of the Huronian covered that stratigraphic interval long known as "Lower Cambrian," which Dr. Emmons named Taconic, and which at a later date furnished primordial fossils in England to reward the acumen of Joachim Barrande. In all this series of strata there is nothing that can be correctly called crystalline. This is verified by Murray's section of the Huronian printed in his report for 1856,[4] as well as by the general section of the Huronian system published in 1863 by the Geological Survey of Canada.[5] This idea of the Huronian on the part of its authors seems to have been adopted by the English geologists from the outset, and has continued to be held by them to this day, and they consequently do not recognize the term in their nomenclature,

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[1] Esquisse géologique du Canada, 1855. Paris. Par W. E. Logan et T. Sterry Hunt. pp. 29-37.

[2] The first use of the term Huronian series, so far as I have been able to learn from the Canadian reports, was by Mr. Murray in his report for 1854, p. 125. Mr. Logan employs the term "Huron Cupriferous formation" in 1857. Brit. Asso. Rep. of Trans. of the sections, p. 60.

[3] Am. Jour. Sci. vol. XLIX. p. 184. (1870).

[4] Geological survey of Canada. Report of progress for the years 1853-54-55-56. Toronto. (1857.) p. 172.

[5] Geology of Canada, 1863.

allowing the term Lower Cambrian to supply the interval covered by it. Another point should be mentioned in connection with this original idea of the term Huronian, viz: It is distinctly avowed[6] that the Huronian embraces the volcanic formations of the shores of lake Superior. These are made the parallel to the trap and associated quartzytes of the north shore of lake Huron. The geological map that accompanies the French document has the Keweenawan throughout the shores of lake Superior, at Thunder bay, and on Isle Royal colored to represent the Huronian, the same as the north shore of lake Huron. This embraces the traps and conglomerates and the amygdaloids as well as the Animike rocks of Thunder bay with their associated greenstones. The Huronian is said, unqualifiedly, to rest unconformably on the Laurentian. This view of the Huronian seems to have continued in favor till 1862.

In the Quarterly Journal of the Geological Society of London (Nov. 19, 1862), appeared a contribution by J. J. Bigsby "On the Cambrian and Huronian formations," which has played a very important figure in its effect on the literature and geology of the Huronian formation. At various times Dr. Bigsby had contributed important articles on the older rocks of lake Superior and of the region further northwest, and his opinion and authority, with English and Canadian geologists, stood in such high esteem that there was no one who would venture to question his conclusions. Still they were at variance with those of Logan, Sir Roderick Murchison, Dana,[7] and nearly all the geologists who had expressed an opinion on the subject, Dr. Dana going so far as to state that the true Cambrian formation did not exist in North America; the same interval being covered, as remarked by Dr. Bigsby, by the Huronian, "as a substitute in place if not in time." Still, after taking a wide survey of the Huronian and the Cambrian, in the light of the conceptions which he held of them, Dr. Bigsby reached the conclusion that they are not the same, but that the Huronian differs markedly from the Cambrian. He placed it on the same plane as the "Second

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[6] Canadian Naturalist. vol. I. 1856. p. 16; Esquisse géologique, p. 29.

[7] Am. Jour. Sci., N. S., vol. XIV. p. 227; Siluria, 2nd Ed. p. 19; A.A.A.S. vol. IX. 1855. Providence meeting, p. 32.

Azoic Group of Norway," and greatly anterior to the Cambrian.

The idea Dr. Bigsby entertained of the Huronian, while professedly based on the original descriptions of Logan and Murray, is widely variant from them. He referred to, and used such parts of their descriptions as suited his purpose, but derived (more largely probably from his own observations about the Lake of the Woods) a "Huronian" that agreed more nearly with that system of rocks which has more recently been designated *Keewatin*, a series of greenish schists, greenstones and gray-wackes, with some argillytes and agglomerates. With that facility which has at various times marked the versatile perceptions of Dr. T. Sterry Hunt, this idea was at once accepted by him, and urged as the correct expression of the Huronian system,[8] and it is probably due largely to his writings that the "greenstone" idea of the Huronian was widely received and accepted favorably by geologists in North America.

Still a different idea is at present entertained by the officers of the Canadian Geological Survey. Perceiving the necessity of admitting into the Huronian the non-crystalline strata described on the north shore of lake Huron, and repeated in 1863 by Sir Wm. Logan in the "Geology of Canada," they are forced to extend the Huronian system from the bottom of the Silurian wherever that may be, or at least from the bottom of the Cambrian, wherever that may be, and if it exist at all in North America, downward to the "Laurentian," wherever that may be. This makes it include not only the original Huronian, and the "greenstone" idea of Bigsby and Hunt, (the Urschiefer of Norway) but also the true "crystalline schists" of a still lower horizon, and so amplifies the term that it well nigh falls to the ground from the burden of its own weight.[9] It should be admitted that the extension of the term downward so as to include strata not embraced in the descriptions and sections published by Logan and Murray (1848-1863) may be to some degree justified by the mapping of the Huronian which

[8]Geognosy of the Appalachians. A.A.A.S. vol. xx. 1871; Chem. and Geol. Essays. p. 269.

[9]Trans. Roy. Soc. Canada. vol. VI. Sec. IV. p. 3. 1888. Presidential address of Dr. Robert Bell.

is seen in the early *Esquisse géologique du Canada* and in the geological map accompanying the Geology of Canada of 1863. Those maps do, in a general way, include strata not described in the text, nor embraced in the sections, even ignoring some Laurentian areas. The original Taconic was roughly laid off in the maps of Emmons, in the same way. The descriptive text, however, and the main idea which the author intended to express, should be the guide in determining how to interpret him, instead of the map, for the map is designed only to illustrate the idea—not the idea the map. If the author's idea be found at variance with his map, by later research, every fair geologist will correct the map instead of the idea. This should be done for the correct Huronian, no less than for the correct Taconic.

We have, then, three conceptions of the Huronian which at different times have been dominant with the Canadian geologists.

1. The original Huronian of Logan and Murray, consisting of fragmental strata, and including the Keweenawan, 1855-63.
2. The "greenstone" Huronian of Bigsby and Hunt, 1863.
3. The expanded Huronian of the present officers of the Canadian survey, embracing some of the primordial quartzytes[10] and extending downward to the "Laurentian."

Principles of Stratigraphy employed. It will be an interesting inquiry to seek for the principles that were relied on by the various geologists in arriving at the foregoing results. Sir William Logan, beginning the Canadian survey in 1842, with Alexander Murray as assistant geologist, was a pioneer not only in the geology of Canada, but of the world. Much of the nomenclature of the science now in vogue has been based on work done either in Canada or elsewhere since that date. Very little positive knowledge of the composition of the earth's crust, or of the alternation and succession of its various parts, then existed. Every rock-terrane below the Potsdam sandstone was at first regarded as "primitive." Subsequently the "metamorphic" strata were recognized existing below the Potsdam sandstone and above the gneiss, though these also were generally regarded as "primitive," a word to which some

[10] The Huronian quartzytes of the Thessalon valley are fossiliferous in Minnesota with Paradoxides and Lingula. Thirteenth report of the Minnesota survey, p. 65; AMERICAN GEOLOGIST, March, 1888. p. 177.

vague idea of geological antiquity was attached. About this time the word Taconic was applied by Dr. Emmons to a part of these intermediate "primitive" strata, which were at first regarded as wholly non-fossiliferous and comparable to the Lower Cambrian of Prof. Sedgwick both in their non-fossiliferous character and in their stratigraphic position. The unfortunate controversy which grew up between Dr. Emmons and his colleagues on the New York survey easily transgressed the Canadian borders and involved the officers of the Canadian survey. From this controversy Logan and his assistant Murray for some years held aloof. He saw in Canada only the "Laurentian" under which term he included all the granites, schists, (crystalline and semi-crystalline), also the gneisses and gabbro rocks he met with—in short everything that he found lying below the Potsdam sandstone.[11] The first distinct use of the term "Metamorphic group" by Mr. Logan, so far as I have observed, was in its application to some gneisses that have since been included in the Laurentian. Indeed Mr. Logan distinctly states[12] that the term Laurentian was designedly substituted for the term Metamorphic series, "since the latter is applicable to any series of rocks in an altered condition, and might occasion confusion." If we may form an opinion from the scanty statements that have been published as to the principles and motives that actuated the authors of the "Huronian system," we are compelled to state that it was their design to give an American name to those strata which had in England been placed by Sedgwick in his Lower Cambrian. Mr. Logan had seen a great series on the north shore of lake Superior in 1846 which, while overlying the "primitive," yet at a later date were seen, on the north shore of lake Huron, to lie unconformably below the "fossiliferous rocks," i.e. the Trenton and Hudson River limestones and shales. Ignoring the early attempt of Emmons to supply an American designation for this same interval (viz. Taconic) and referring to areas in the Northwest which were then and were for many years practically inaccessible to the geologists of the world, and having the favorable coöperation of all the opponents of Dr. Emmons' *Taconic*, the name that was published in Paris and was subsequently employed in the reports

[11] Canadian reports for 1852-53; 1849. p. 8.
[12] Report for 1852-3. p. 8.

of the Canadian survey, became current in nearly all American geological literature. If we examine carefully the reports of the Canadian survey we fail to discover any description of the Huronian, as such, till after 1855. We find no section of the rocks on the north shore of lake Huron nor on the shores of lake Superior by means of which a correct idea can be obtained of the Huronian series until 1857,[13] yet the term seems to have been in current use to some extent since 1854, since it appears incidentally in the reports for that year, and for 1855. The characters of the rocks of the Huronian, as finally and fully published, are given in the geology of Canada, 1863, pp. 59-66, and their typical area is mapped in the atlas accompanying that volume. It is to this authority, therefore, that it is necessary to refer, and by this final presentation must the Huronian stand or fall. It is only necessary to say at this place what has been said by Prof. Irving and by others who have recently examined these strata, that they consist of non-crystalline rock-species—mainly conglomerates, quartzytes and slates, with some limestone, cut by and interbedded with eruptive rocks, mainly dolerytes and diorytes. It will be noticed, however, that in this last presentation of the Huronian an important change was made in its upward extension. The volcanic rocks of lake Superior are set off by themselves under the designation "Upper Copper-bearing rocks of lake Superior," and are divided into two groups, the lower "consisting of bluish slates or shales, interstratified with sandstones and beds of columnar trap, and the upper, of a succession of sandstones, limestones, indurated marls and conglomerates, also interstratified with trap which is often amygdaloidal." Of these the lower group is what was afterward named Animike, and the upper group is, as I have shown in my 17th report on the Minnesota geological survey, pp. 52-55, the equivalent of the upper quartzytes of the original Huronian and lies unconformably on the lower group.

If we revert next to the reasons that induced Dr. Bigsby to remove the Huronian from parallelism with the Lower Cambrian we shall find a curious medley of assumption, inference from insufficient data, and of generalization from ill-supported inference. It had been argued by Mr. Thomas Macfarlane in

[13] Canadian report of progress for the years 1853-54-55-56. p. 172. Report for 1856.

1862,[14] that the Huronian of Canada is the equivalent of the quartzose member of the *Urschiefer* of Norway, but he evidently derived his idea of the Huronian from his knowledge of the crystalline schists of lake Superior, and not from a study of the true Huronian. But Dr. Bigsby goes much further than that, in that he attempts to show, or at least to strongly suggest, that the Huronian system is not what its authors supposed it was, but is the equivalent of a system of rocks much older; and in this he was followed, as already stated, by Dr. T. Sterry Hunt, who derived from his knowledge of the collections he had seen, and from hand samples sent him from the regions of lakes Superior and Huron, the well known "greenstone" conception of the Huronian which has been presented in Dr. Hunt's papers.

Without stopping to protest against the position in the English geological series in which Dr. Bigsby places the Cambrian, it is sufficient here to call attention only to the errors that he falls into respecting the Huronian, remarking only in passing that he places the entire primordial zone of Barrande, whether in America, Scandinavia or Bohemia, as the "immediate successor of the inhospitable Cambrian."[15]

In the first place Dr. Bigsby regards the Huronian as conformable on the Laurentian, which is at variance with the statement of Messrs. Logan and Hunt in the original announcement of the name,[16] as well as the later descriptions by Mr. Logan, notably that in a paper read before the American Association for the Advancement of Science in 1857.[17] This is an element in his discussion which affects materially the correctness of his conclusions.

In the next place Dr. Bigsby identifies the "Huronian" of the region of Marquette, Mich., with that of the north shore of lake Huron from the description of the former by Foster and Whitney, which he quotes as follows: "As an alternation of beds of great thickness, of gneiss, of chloritic, talcose, argillaceous and siliceous slate, of quartz, of saccharoidal and crystalline limestones and serpentines, all much contorted, highly inclined—nowhere having a sedimentary aspect and most

[14] Canadian Naturalist. vol. VII. pp. 1-20 and 113-127.
[15] Quart. Jour. Geol. Soc. vol. XIX. Part I. p. 43. Nov. 10, 1862.
[16] Esquisse geologique du Canada, p. 29.
[17] Report of the A.A.A.S. 1857. p. 45. (Part 2.)

metamorphic near the lines of igneous outburst."[18] It is not difficult to mention in this enumeration of the characters of the Azoic of the south side of lake Superior, several important departures from the lithology of the Huronian of the typical region as described by Messrs. Logan and Murray, and as finally published by Logan in 1863.

(a). In the typical Huronian no gneiss is mentioned.

(b). In the typical Huronian no serpentine is mentioned.

(c). In the typical Huronian the inclination of the beds is generally less than 50°, sometimes not over 10° or even 3°.

(d). In the typical Huronian there is not an absence of the sedimentary aspect, but its presence is one of its strong physical features.

(e). In the typical Huronian the beds are not "much contorted." They are faulted but the line of strike is persistent for long distances.

The other characters enumerated pertain to the Huronian equally with the lower terranes, and can not be considered diagnostic of either, while the points of disagreement are so numerous, and so characteristic of the older formation that they warrant us in regarding the rocks exhibiting them as non-Huronian. Indeed it becomes evident that Dr. Bigsby's Huronian was not Huronian at all. His comparisons, whether from America or from Norway, are very fair, but abundantly sufficient to show that he had in mind a series of strata that have been found to lie in all places where their superposition has been seen, in a relation of non-conformity with the typical Huronian.

The principles of stratigraphy which have induced the present officers of the Canadian survey to embrace so wide a range of time, and so varied a lithology in the Huronian are difficult to understand and express. The only justification for it, partial though it be, that I have been able to learn, consists in the partially incorrect mapping of the Huronian by Logan, Murray and Hunt.[2] But as has been already remarked, those maps should be corrected to agree with the descriptive text.

[18] Report on the geology of the lake Superior land district. Part II. p. 14.

[2] It should be stated, however, that nearly all the geologists of Michigan and Wisconsin have included the same wide range in the Huronian, in their official reports. Compare the reports of Brooks and Pumpelly, on the Geology of Michigan, and of Chamberlin, Irving, Sweet and Wright on the Geology of Wisconsin.

The true idea of the Huronian is found in the sections given in the *Geology of Canada, 1863*, and this idea is represented by the typical Huronian area as mapped between the Thessalon and Missasaugui rivers, and thence northwestwardly to Port Finley and the southeastern shores of lake Superior.

In a recent address before the Royal Society of Canada,[11] Dr. Robert Bell has presented the views of the present officers of the Canadian survey, in support of the expanded Huronian. An examination of this interesting paper results in bringing out the following points, at variance with what has recently been presented by Prof. R. D. Irving and other United States geologists.

1. The original idea of the Huronian, as understood by the Canadian survey, extended from the "Cambrian" to the Laurentian, covering all the crystalline schists. Dr. Bell refers for authority for this to the *Geology of Canada, 1863.* This is a question of fact, and anyone who takes the trouble to examine the descriptions of the Huronian, in the *Geology of Canada. 1863*, can satisfy himself quickly. These descriptions are found on pages 50 to 66, and 841 to 844. We have failed to find the term "crystalline schists," or any term that can be taken as an equivalent for it, anywhere in those pages —or in any other part of the volume where the Huronian is mentioned.

2. *The Huronian is conformable on the Laurentian, and no instance of unconformity has yet been found in Canada.* It is not necessary to repeat what has already been said on this point in speaking of Dr. Bigsby's treatment of the Huronian. Not only did Logan mention, in numerous instances, the non-conformity of the Huronian on the Laurentian, but recently such have been fully described by Prof. Irving at a point about three miles east of the Thessalon river, on the north shore of lake Huron;[12] and Prof. Irving's observations have been confirmed by a more recent visit to the same place by members of the excursion party from the late Toronto meeting of the American Association for the Advancement of

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[11] Trans. Royal Society of Canada, vol. VI, sec. 4, p. 3.

[12] Seventh annual report of the U. S. Geol. Survey, p. 429. Logan's descriptions of unconformity are to be found in *Geology of Canada, 1863* p. 50; *Proc. Am. Assc. Adv. Sci.* 1857, Part 2. p. 45, Esquisse géologique du Canada, 1855, p. 29; *Quart. Jour. Geol. Soc.*, London, vol. 21, 1865, p. 46.

.Science. There is no doubt that that "Huronian" which Dr Bell all the time alludes to is conformable on the crystalline schists and the crystalline schists on the Laurentian, a fact which has been published repeatedly by officers of the Canadian survey and in the reports of the Minnesota survey.

3. *It is not just to the founder of the Huronian system to restrict the term to the type Huronian.* Here we must differ squarely from Dr. Bell. It would be unjust not only to all subsequent investigators, but more so to the authors of the term, not to do so. If we are not to accept an author's definition of his own discovery, who shall set metes and bounds to it? Again, Dr. Bell in several instances, insists on adhering to Logan's descriptions, "which" as he says, "are as clear as language can make them."

4. *The comparatively undisturbed condition seen in the Huronian on lake Huron is not the rule in the "Huronian" elsewhere.* But by the term "Huronian" here Dr. Bell indicates the strata which are in dispute, and which we admit are much more crumpled—a circumstance which, with other differences, has led to their separation from the true Huronian. And when Dr. Bell states that "the same rocks" are highly crumpled and tilted in other districts, we respectfully ask for proof that they are the same that Logan included in his original descriptions.

5. "*As a matter of fact crystalline schists, such as those that prevail among the Huronian rocks of lake Superior are largely associated with the quartzytes and slate-conglomerates of the lake Huron region.*" We would respectfully ask that they be pointed out. Not only has Logan given a typical section, without including them, but Prof. Irving failed to find them, and later still, my brother and myself made a pretty thorough examination without seeing them. We venture to suggest that (as I know from observations made the past summer) the crystalline schists exist only outside of the region described and mapped in the *Geology of Canada*, *1863*, begining, on the east, not far from Serpent river, and extending thence eastward to the recognized Laurentian. This is doubt less what Dr. Bell would consider "associated largely with the quartzytes and slate-conglomerates," but it is the same kind of association that might be applied to the Laurentian gneiss which occupies the lake shore for some miles between

the Thessalon and Missasaugui rivers. The fact is, "there must be a beginning and an ending, a top and a bottom," as Dr. Bell insists, and the bottom is placed by Logan so far west that this schist is not included. The fact that he has included it in his map of 1863 (which was really constructed in 1865) has no force except such as would also include some Laurentian in the Huronian, since his map of 1855 actually does cover the belt of Laurentian mentioned.

The usage and understanding of the Canadian survey at the present time should be accepted as sufficient authority as to what the Huronian really is. The geologists of the rest of the world will hardly hold their mouths shut when they find the Canadian survey of 1855-63, contradicted by the Canadian survey of 1888, and when the question involved is so closely connected with their own work. The principles of science are not to be determined by authority.

7. *The gradual stratigraphic passage from one formation to another, even in the entire absence of fossils, is a better place to separate between them than at the point where a physical break occurs,* because of the greater "convenience of description and classification of our facts." (p. 7.) The simple statement of this argument is sufficient to refute it.

8. *It is not necessary that all Huronian rocks should be the equivalents of the "type series," described by Logan and Murray, as claimed by Prof Irving.* Here we differ as widely as the poles, for we think that quality of equivalence is the cardinal criterion to judge by.

9. *The restriction of the Huronian as proposed is contrary to the view of its founder.* On the contrary it is evident to any one who examines the original authorities, that its limitation downward, at the lower Slate Conglomerate (or with the lower gray quartzyte) was in accordance with the views of its founders. Finally:

10. *The preponderance of rocks of volcanic origin in the "Huronian" is a character that is found to mark it everywhere, indicating that an era of volcanic outbursts sets it off from the Laurentian.* This fact is true of the Huronian as expanded, but it is not of the Huronian of Logan and Murray, which consists of conglomerates, quartzytes and limestones, in the proportion of 18,000 feet to 5,000 feet of diabase and dioryte, the latter not being worked over by sedimenta-

tion, as in the "igneous rocks" of the expanded Huronian, but massive, crystalline, and in the form of unmodified overflows.

The new departure necessary. Why? It will have been observed, already, that the complications that arose from the promulgation and acceptance of the idea of the Huronian as entertained by the majority of geologists up to a very recent date, rendered it necessary to revise *de novo* the classification in vogue. It is to the late lamented Prof. Irving, that we owe the initiative in this direction, so far as it pertained to a re-examination of the type region, although the studies of the writer, led him in 1884[13] to call attention to the confusion that existed. In this re-examination of the work of Logan in the stratigraphy of the oldest rocks, we are impressed with the essential correctness of his original conception of the Huronian formation, and we think it is no more than justice to an early pioneer in American geology to call attention to it, and to vindicate his work from the errors that appear to have been fastened on it by the Canadian geologists and by those in the United States that have followed them.

The methods of the new departure. The methods of work that geologists in the United States are now employing on the older rocks are markedly different from those resorted to by Logan, and his assistant, Alexander Murray; and in so far as the methods are improved are the results more reliable. The early geological work in America consisted largely of topographic description, and sketch-mapping. The nature and distribution of the rock-terraces could not be minutely worked out. Not only was the time allowed for such work not sufficient (nor the money), but the microscopic examination of the intimate structure of the different rocks was almost unknown as a geological adjunct. With the lapse of time, and the increased appreciation of geological surveys, the public authorities have granted more time, means, apparatus and general co-operation. Much of the early work has to be reviewed. New surveys are made where the first had been pronounced "finished." While it is necessary to go again over much of the early work, it is necessary to treat it with strict justice, and in doing so we have to be guided by the publish-

[13] Address before Section E., A. A. A. S. Philadelphia, 1884.

ed reports and other papers of the early geologists in forming an opinion as to what they believed, rather than by interpretations and traditions that have grown up from them. It is intended here only to call attention to the improved methods of work. These consist of the following, as distinguished from the old methods:

1. Painstaking field-work, extended and repeated over a small area, map in hand, accompanied by descriptions and sketches made on the spot.
2. Sampling of all changes in rock-species from place to place with notation *in the field*, referring each sample to its place in the accompanying field descriptions.
3. Chemical and microscopic examination of the samples in the laboratory.
4. Combination of field-studies with laboratory work, and the publication of the results.

These methods have been pursued in some parts of the Northwest, at different times recently, by different geologists in some of the areas that have been included in the expanded conception of the Huronian, with surprisingly concurrent results. Without mentioning the work of the Minnesota survey which is not yet carried to completion, I shall refer only to the examination of the rocks in the vicinity of Sudbury, by T. G. Bonney in 1886,[14] the thorough microscopic work of Prof. R. D. Irving, accomplished for the United States geological survey,[15] and his discussion of the elements of Huronian stratigraphy published recently in the Seventh annual report of the same survey, and to the work and results of Dr. A. C. Lawson of the Canadian geological survey, in the regions of the Lake of the Woods and Rainy lake, on the international boundary line west of lake Superior.[16]

Similarly accurate field-work has also been done in Michigan by Dr. C. Rominger,[17] resulting in a similar correction of the early survey of major T. B. Brooks.

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[14] Quart. Journ. Geol. Soc. London, May 1886, p. 83.

[15] Third Annual Report, U. S. Geol. Sur. 1881-82, pp.93-180 Monograph No. v. The copper-bearing rocks of lake Superior, 1883; Bulletins No. 8 and 23.

[16] Report on the geology of the Lake of the Woods, with special reference to the Keewatin (Huronian?) belt, of the Archæan rocks. A. C. Lawson; 1885; Reports of progress of the Canadian survey for 1885. Also Geology of the Rainy Lake region; Reports of the Canadian survey for 1887.

[17] Geological survey of Michigan, Upper Peninsula, 1878-80, Vol. IV.

Some of the results of the new method of work may be here re-capitulated somewhat more systematically, viz.:

1. The Huronian, as defined by Logan and Murray has been re-examined, and the essential correctness of their stratigraphy and of their geological map has been affirmed.

2. Below the strata enumerated by them is a great series of strata divisible into at least two parts, placed unconformably below the Huronian. These have been examined and named Keewatin and Vermilion groups, but by the Canadian survey they are claimed still as belonging in the Huronian.

3. The strata of the Huronian proper are non-crystalline and plainly fragmental, while those underlying strata are distinctly different, the Keewatin consisting very largely of volcanic ejecta, simply arranged and consolidated by the agency of oceanic water and later metamorphic forces, and the Vermilion of the same re-crystallized by hydrothermal fusion.

4. That the distinctness of the true Huronian is everywhere observable both on account of its different lithology and its basal fragmental conglomerates that lie unconformably on the Keewatin, on the Vermilion, and even on the Laurentian.

5. I would add a further general truth, to which the work of the Minnesota survey has arrived, viz: the true Huronian is divisible into two non-conformable parts, the lower being the slate and slate conglomerates and the upper the quartzyte and quartzyte conglomerates.

6. And still another, the upper part of the true Huronian was characterized by frequent and enormous outflows of basic eruptive rock, and by some of acid rock, the equivalent, as at first supposed by Logan and Hunt, of the recently named Keweenawan.

The re-construction of the Huronian and the treatment of the correlated terranes. The results above enumerated are sufficiently important to call for a sweeping reconstruction of the prevalent idea of the Huronian system. That it is a *system* is shown by its wide range of strata (at least 18,000 feet), its unconformable relations to the underlying and overlying series, and its relations of apparent identity to other terranes (Taconic, Lower Cambrian) which are recognized as systems by the common consent of geologists. That the Huronian has been made to include much more than it did originally is not the fault of the authors of the name. It is but justice to them

that their statements be taken for exactly what they are. If correction is to be made, it is apparent that the sooner it is done the better it will be for the science both at home and abroad.

How this correction will affect two other terms, the *Taconic* and the *Lower Cambrian*, it is not my intention to inquire fully at this time. I would only call attention to the nearly, if not quite, parallel and almost identical lines of thought that prompted these other, and earlier, geological terms, and the great approximation they show to identity of stratigraphic position.

JURA, NEOCOMIAN AND CHALK OF ARKANSAS.

JULES MARCOU.

The second volume of the *Annual Report of the Geological Survey of Arkansas, for 1888*, issued August last is one of the most important contributions yet made to the geology of the country southwest of the Mississippi river. The title is: "The Neozoic geology of southwestern Arkansas," by Robert T. Hill, assistant geologist. On the back of the volume the title is only "Mesozoic." I shall confine my remarks to the Mesozoic series, which is the most valuable part of the work, passing over the first six chapters, on the geography, topography, Post-Tertiary and Tertiary formations. It is not because the first part of the volume is not worthy of consideration; on the contrary, like the rest, it is a remarkable and well digested work, worthy of being reviewed by a specialist, who can better render justice and appreciate the stratigraphy of the Cainozoic than myself.

The lower Cretaceous, or Comanche series, is composed of three groups. The lowest is the "Trinity division." Although professor Hill has spoken, in several of his papers on the geology of Texas, of that group under the names of "Dinosaur sand," 1887; "Basal sand," 1887; "Trinity beds," April, 1889; and "Trinity basal littoral beds," May, 1889; he had not given a true description before publishing his report of southwestern Arkansas. He even hesitated before placing it in the Cretaceous system. In his first paper of April, 1887, he put it outside of the lower Cretaceous—a true and excellent classification; then he enclosed it in his Comanche series, saying,

however, that "the lowest marine fauna of this division may prove Jurassic affinities" (*Amer. Jour. Sci.*, vol. XXXIV, p. 306, October, 1887); but finally he created a division for it of the lower Cretaceous, which, according to his last view is composed of the Washita, Fredericksburg and Trinity divisions.

Chapters XII and XIII are devoted entirely to the Trinity division, and are certainly the two most important chapters of the report. All is new there, stratigraphy and palæontology. Professor Hill gives a detailed description of its stratigraphy in chapter XII, containing an important section, p. 119, of the gypsum bluff, two miles south of Murfreesboro, Pike county. The thickness of the division is 400 feet in average. It contains gypsum in several thin bands of a total thickness of only 25 feet; and the fossils are disseminated in blue and white marls, sometimes sandy, finishing at the base by an irregular deposit of lignite and bones of saurians.

In Texas the Trinity division is much developed and covers vast surfaces. It lies in discordance of stratification upon the Palæozoic rocks of Arkansas, and upon the Silurian, the Carboniferous, the Dyas and the Trias of Texas.

Chapter XIII is entitled: "Palæontology of the Trinity division." The molluscan fauna, which is the only one described, "bears remarkable resemblance to forms from the upper Purbeck and basal Neocomian, or Wealden beds of Europe." A review of all the species described and figured by professor Hill is necessary to arrive at the true age of this division. First we have *Ammonites walcotti* Hill, Plate I. The name is unfortunate because it creates a confusion with *Ammonites walcotii* Sowerby, who has described under that name, in his celebrated *Mineral conchyliology* vol. II, p. 7, Plate 106, 1815, an Ammonites of the upper Lias, with which the Ammonites of Arkansas has no affinities whatever.

Professor Hill is right in saying that "it resembles *Ammonites yo* d'Orbigny, of the lower Neocomian;" only the reference to the lower Neocomian is an error, because d'Orbigny specially says that the Ammonites he describes under the name *yo*, belongs to the Kimmeridian of Boulogne-sur-Mer. The species of Mr. Hill is new; but is closely allied to *Ammonites yo*, being much smaller, and the ombilix is not so narrow. It resembles *Ammonites litocerus* Oppel, with its

rounded back and its indistinct flexuous line on the side. It is a true discoid Ammonites, related to the three rounded-keel *Ammonites litocerus yo* and *contejeani* Thurmann; three species of the upper Jurassic system of central Europe ranging from the *Ammonites* (*Oppelia*) *tenuilobatus* zone to the Portlandian. It has also some resemblance to *Oppelia latilobata* Waagen of the lower Oölite of Poland. The locality of that Jurassic Ammonite is at the mouth of Caney creek, branch of Prairie creek, near Murfreesboro, Pike county, Arkansas.

Pleurocera strombiformis Schloth. It resembles a *Cerithium* or a *Nerinea*, related to *Cerithium pseudoexcavatum* de Loriol, as well as to *Nerinea nodosa* Frederick A. Rœmer and *Nerinea speciosa* Voltz; all upper Jurassic gasteropods of Boulogne-sur-Mer, Hanover and Porrentruy. The fig. 7a, Plate II, of Mr. Hill, shows the opening with a fold so common in *Nerinea*. It will require better specimens and better figures before dividing the genus of that most common and characteristic shell of the Arkansas and Texas Trinity beds.

Vivipara cossatotensis Hill, the specimens being only "poorly preserved casts," have deceived the author; they do not belong either to the genus *Vivipara*, nor to *Liaplacodes*, but to *Natica*. The species is allied to *Natica zangis* d'Orbigny of the lower Oxfordian. *Buccinopsis conradi* Hill; it is almost identical in general contour with the figure of *Buccinopsis parryi* Conrad." Professor Hill's fossil is a *Natica*, allied to *Natica athleta* d'Orbigny, of the Portlandian of France. It differs greatly from *Buccinopsis parryi* in the mouth, and on account of ribs on the spine.

Ostrea franklini Coquand. This species was named in my library in Paris in 1868, by Coquand, who came to ask me the permission to study my American *Ostracæ*, for his "Monographie du genre Ostrea," in two parts. Coquand published only the first part, the Cretaceous species, the second part being left in manuscript unfinished. He recognized that the *Gryphæa tucumcarii* and the *Ostrea marshii* of the Tucumcari area (New Mexico) are Jurassic species, and he did not put them in the Cretaceous part of his Monograph, placing there only the *Gryphæa pitcheri* typical form, as described and published by Morton, F. Rœmer and Marcou.

After studying my specimens, Coquand asked me for any

American publications I might possess, containing Mesozoic *Ostraceæ.* I first showed him the "Synopsis of the mollusca of the Cretaceous formation," by W. M. Gabb, 1861, unknown to him; and then the *Second Report of a Geological Reconnoissance of Arkansas*, by D. D. Owen, 1860, a work entirely unknown in France. He saw at once that the *Ostrea cretacea* ? Morton, on plates VII and VIII, was a new species, and he asked me for the formation and locality. But it was impossible to answer, because the report does not describe the species; the plates prepared by Owen were found after his death, but without text of any sort; and Mr. E. T. Cox thought best to publish them without explanation. From my scanty practical knowledge of the geology of Arkansas, I was inclined to think that the species must come from somewhere near the locality of the *Gryhæa pitcheri*, in the Kiameshia creek plains, and then that it was a Cretaceous species. Coquand said that it was different from all the Cretaceous *Ostreæ* that he knew of, and asked me to name it. I proposed *Ostrea oweni*, but he preferred *Ostrea franklini*, on account of Benjamin Franklin, always popular among Frenchmen. So it came that the most characteristic and common of the fossils of the Trinity division, or upper Jurassic of Arkansas and Texas was named by a foreign palæontologist, who never came to America, and was referred wrongly to the Cretaceous system.

Professor Hill gives three plates of "figures of every possible type of variation," plates V, VI and VII, almost all collected at the same spot, in a breccia limestone, five feet of thickness, composed entirely of these shells, near Murfreesboro, Pike county, Arkansas. After a careful study of the plates and of a few specimens, I fully believe that we have there four distinct species.

On plate V, from figure No. 1 to No. 10, we have a variety of the *Ostrea virgula.* The true and original *Exogyra virgula* Goldfus is a little larger and more hooked or virgulated, if we can make use of such a word. I must say that I have seen specimens, referred to *Ostrea virgula* in the Jura mountains and in Burgundy, exactly like figures 2, 3 and 7 of Mr. Hill. So, on the whole, we can say that we have in the Trinity beds of Arkansas, the *Exogyra virgula* so characteristic of the lower part of the Portlandian or Salins marls of central Europe.

The figures 11, 12, 13, 14, 15, 17 and 18 of plate V, and figs. 20, 22, 23, 24, 26, 27 of plate VI, and figs. 28, 29, of plate VII represent very well the true and original *Ostrea franklini* of Owen and Coquand. Professor Hill, in his description, confounds the upper valve with the lower. The *O. franklini* possesses only a very distant relation with the *O. dubiensis*, a much smaller and less pointed species described by Contejean and Etallon, but is truly related and allied to *O. acuminata*, by its pointed and acuminate lower valve.

Then we have on plate VI, figs. 19 and 25, an oblique form of *Ostrea*, which belongs to the *O. rœmeri* Quenstedt (Der Jura, tab. 77, fig. 22, p. 625); a species of the Argovian group of the Jura.

And finally fig. 16 of plate V and more especially fig. 30, plate VII, are closely allied to a very common and characteristic form of the lower Oölite species of the Vesulian group, called *Ostrea acuminata* Sowerby, in the Jura mountains.

At all events, all the forms figured by professor Hill are Jurassic forms, connected and allied with the *Ostrea virgula*, *O. rœmeri and O. acuminata.*

Modiola, sp. ind. Hill, is a *Mytilus* allied to *Mytilus longævus* Contejean of the Sequanian (Lower Kimmeridian) of the Jura (*Lethea Bruntrutana*, p. 224, plate XXIX, fig. 9).

Arca gratiota Hill. It is one of the largest *Arca* of the Jurassic system. It resembles *Arca laufonensis* Etallon (*Lethea Bruntrutana*, p. 215, plate XXVII, fig. 4 of the Sequanian of Laufon, Solenre, Switzerland).

Arca (Barbatia) parva missouriensis Hill, plate IV, fig. 5, is related to *Arca inæquivalvis* of the Jura mountains. Mr. Hill refers "also probably" fig. 4a, 4b of the same plate to that species. Figure 4a belongs to a *Nucula*, and fig. 4b can not be referred to an *Arca*. As to plate II, fig. 22, also considered by professor Hill as belonging to *Arca parva missouriensis*, it is a *Nucula*, allied to *Nucula rostralis* Lamk. of the upper Lias of Salius (Jura).

Cyrena (Corbicula?) arkansaensis. It is *Corbiscrenata* Cont. or an extremely close species (*Kimmeridian*, p. 55, plate XIII, fig. 10 and 11; and the *Lethea Bruntrutana*, p. 187, plate XXIII, fig. 2). Kimmeridian at Porrentruy and Montbelliard.

Corbicula? (Astarte?) pikensis Hill. It is an *Astarte*

not so large as *Astarte celtica* Cont. of the Kimmeridian of Montbelliard; but larger and more thick than *Astarte pesolina* Cont. of the Portlandian or Salius limestone of the Jura.

Cardium? sevieriensis Hill is a good species.

Anomia sp. ind. are very common in the Sequanian and Portlandian of Porrentruy (Switzerland).

From the preceding remarks we see that the conclusions as to the age of the Trinity division, are that it represents in Arkansas and Texas the Jurassic system, and more especially the Upper Oolite from the Corallian to the top of the Purbeck or Salius limestone of the Jura.

Some forms of fossils alluded to point even to a part of the Jurassic system older than the Corallian and Kimmeridian. And I ought also to speak of two specimens of a *Gryphæa*, which professor Hill had the kindness to offer to me, and labelled by him "*Gryphæa pitcheri* Morton, base of Cretaceous, one thousand feet below other varieties of *G. pitcheri;* occurs by millions at Burnet, Texas." They belong to a Jurassic form entirely different from the *G. pitcheri* but related to *Gryphæa calceola* Quenstedt, and more so to *Gryphæa arcuata* Lamk. of the Lower Lias. It is a new species, three or four times smaller than the *G. arcuata*, but otherwise closely allied to it. It would not be surprising if the great division called "Trinity" by Mr. Hill, and occupying a great surface in Texas contains the whole Jurassic system of central Europe.

Revised list of fossils of the Trinity formation in Arkansas.

Ammonites walcotti Hill, not Sowerby. An upper Jurassic form.

Pleurocera strombiformis Schloth. A *Cerithium?* or *Nerinea?*

Vivipara cossatotensis Hill. A *Natica*.

Buccinopsis? conradi Hill. A *Natica* allied to *N. athleta* d'Orb. of the Portlandian.

Ostrea franklini Coquand. Allied to *Ostrea acuminata* of the French Jura.

Ostrea virgula Goldfuss. Portlandian of France and Switzerland.

Ostrea rœmeri Quenstedt. Argonian of the Jura.

Ostrea, closely allied to *O. acuminata* of the lower Oolite of the Jura.

Modiola sp. ind. Hill. A *Mytilus* allied to *M. longævus* Cont. Sequanian of the Jura.

Arca gratiota Hill; allied to *A. laufonensis* Etal. Sequanian of the Jura.

Arca (Barbatia) parva missiouriensis Hill, related to *A. inæquivalis* of the Jura.

Nucula, allied to *N. rostralis* of the upper Lias of Salius (Jura).

Cyrena (*Corbicula?*) *arkansaensis* Hill. A *Corbis* closely allied to *C. crenata* Cont. Kimmeridian.

Corbicula? (*Astarte?*) *pikensis* Hill. It is an *Astarte*.

Cardium? sevieriensis Hill.

Anomia. sp. ind. Hill. A genus very common in the upper Jura.

Professor Hill is inclined to regard this invertebrate fauna as a brackish water fauna, going so far as to say that "the shells are all of forms whose living representatives are known to inhabit brackish waters," and comparing them to forms from the upper Purbeck and basal Neocomian or Wealden beds of a part of central Europe. I can not agree either with the characters of brackish fauna or the Wealden or Neocomian age of the Trinity formation. The molluscan fauna is a marine fauna, littoral to be sure, but no mixture of fresh water forms exists so far. As regards the age, we have in Texas and Arkansas the true equivalent and homotaxis of the Neocomian and Wealden of central Europe in the Frederick division of the Comanche series of professor Hill; and the Trinity division is older, corresponding with the upper Jurassic, from the Purbeck included down to the Oxfordian.

Chapter xv, "Résumé of the Cretaceous group" of professor Hill's important volume, deals mainly with what he calls: "two misconceptions concerning the Cretaceous formation," giving excuses for the opinions expressed repeatedly and maintained contrary to the facts observed and recorded by me as far back as 1853, and condensed a last time in the clearest way in my paper of 1861: "Notes on the Cretaceous and Carboniferous rocks of Texas" (*Proceed. Boston Soc. Nat. Hist.* vol. VIII, p. 86), where will be found an exact section of the Cretaceous strata of Texas, showing that in America we have a complete series of strata of the lower Cretaceous or Neocomian and Aptian, middle Cretaceous or Green Sand and Turonian, and upper Cretaceous or Senonian; only I did not give the details, which were unknown to me.

On p. 166 professor Hill gives a diagram of the stratigraphic occurrence and range of the principal species of the genus *Ostrea*. It is a very instructive table:

Exogyra costata green sand.—*Gryphæa vesicularis* Lamk.

Exogyra ponderosa marls.

Rocky Comfort chalk. No *Ostrea*.

Base of Rocky Comfort chalk (Dakota-Niobrara epochs)—*Ostrea bellaplicata* Shumard.

Ouachita Division. — *Gryphæa sinuata* var. *americana* Marcou; *G. pitcheri*, dilate var. Hill (not Marcou); *Exogyra arietina* Rœmer; *Ostrea diluviana* Lamk.

Frederickburg Division.—*Gryphæa pitcheri* (type) Morton; *Ostrea flabellata* Goldfus.

Transitional Jura-Cretacic (Trinity Division) — *Ostrea franklini* Coquand.

Jurassic? (Tucumcari beds)—*Gryphæa dilatata?* Marcou; *Ostrea marshii* Marc.

The horizontal line above indicates a great break.

It is certainly a progress and a great one after the curious diagrams of Messrs. F. Rœmer, James Hall and Benjamin F. Shumard; but it shows how difficult it is to return to a good and logical classification, when an erroneous one has been used and maintained, by all means, against plain stratigraphical, palæontological and lithological facts, during more than thirty years.

Accepting the diagram of professor Hill, which is far more complete than I was able to make in 1853-61, for want of practical detailed knowledge, because the reader must have always in mind, that when I made observations north of Texas, it was in a direct line and during a heavy march, under a military escort, and necessarily extremely limited; only a sort of first glimpse at the geology of the 35th parallel—accepting that diagram, I shall give one, as I understand now the stratigraphic occurrence of the principal species of *Ostrea*.

Tertiary, beginning with the Laramée group.

Break.—

Fox Hill group or Albuquerque sandstone.
Exogyra costata and *Gryphæa vesicularis* beds. } or Senonian.
Exogyra ponderosa marls.

Dakota group of Galisteo.—*Ostrea congesta* Conrad; or Turonian.

Break.—

Greenish marly limestone of the junction of Little river with the Canadian river (Indian territory), or Cenomanian.

Break.—

Comanche series; Washita Division, or Albian, Aptian and Urgonian —*Exogyra arietina* Rœm., *Gryphæa sinuata* var. *americana*. Marc. and *Gryphæa* n. sp. ind. called *G. pitcheri*, dilate var. Hill (not Marcou).

Comanche series; Frederickburg Division, or Neocomian.—*Gryphæa pitcheri* Morton, Rœmer and Marcou; *Exogyra flabellata* Goldfus.

Break.—

Jurassic (Trinity beds)—*Exogyra virgula* Goldf., *Ostrea franklini* Coquand, *Ostrea rœmeri* Quenst. and *Gryphæa* allied to *arcuata*.

Jurassic (Tucumcari beds)—***Gryphæa dilatata*** **var.** ***Tucumcarii*** **Marc. and** ***Ostrea marshii*** **Sow. and Marcou.**

Under the title *Gryphæa pitcheri* Morton, professor Hill gives, at pp. 168-173, a long and quite correct account of the confusions and controversies created by my adversaries. I shall only point out two errors. Professor Hill thinks that "this species has such a striking Jurassic aspect;" it is a very incorrect view, which he would not have taken if he had had a practical knowledge of the Jurassic and Cretaceous European systems; for at first sight, with my long experience of Jurassic and Cretaceous in the Jura mountains, I recognized the Neocomian form of *Gryphæa*, so characteristic in *Gryphæa couloni* of Neuchatel; and I had no hesitation to say in 1853 when in the field at Comet creek, on the bank of the Washita river, that I had before me the equivalent and the homotaxis of the Neocomian great formation of Europe.

All that professor Hill says about my figures 1, called by error (3), and 2, called by error fig. (1), of the *Gryphæa dilatata* old and young, is incorrect; my figure 2 is not a "small and imperfect figure," but on the contrary an excellent drawing of a young individual of *G. dilatata* var. *tucumcarii*, which has nothing to do either with the *G. pitcheri* Morton or the *G. pitcheri* variety dilate of Hill.

For the first time, thirty-five years after I made my exploration in the Indian territory, Texas and New Mexico, a practical geologist, who knows stratigraphy, has seen the Tucumcari area. Professor Hill, after a few hours' stay at Little Tucumcari, returned convinced that the *Gryphæa tucumcarii* is not the *Gryphæa pitcheri*, and that the "unquestionable Cretaceous" beds of Messrs. James Hall, the Shumards and J. S. Newberry belong to the Jurassic system.

Professor Hill has an interesting chapter XIV, on the presence of "Chalk in the North American Cretaceous." He says that "although certain Cretaceous beds * * * of the Nebraska formation of the upper Missouri, have been exceptionally alluded to as of a chalky nature * * * ;" "the term *chalk* has been studiously avoided in lithologic description" by American writers, because they have "the idea that *true chalk* does not occur in the United States." This is rather too exclusive and incorrect. Evidently my discovery of the *true chalk* near Sioux City (Iowa) and in Nebraska in 1863, has

escaped his notice. In my: "Reconnoissance géologique au Nebraska" (*Bulletin Soc. Geol. France*, vol. XXI, p. 145), I say: "In my visit at the Verygood's quarry, I was struck with the extremely chalky lithological characters of the rocks, which have reminded me more than anything I saw before in America of the *chalk* of the Paris and London basins." And three years later, at the meeting of the 19th of Nov., 1886 of the same society in Paris, in reading my paper: "Le terrain Crétacé des environs de Sioux City de la mission des *Omahas* et de Tekama, sur les bords du Missouri" (*Bulletin Soc. Geol. France*, vol. XXIV, p. 56), I took the precaution to carry with me pieces of rough *chalk* taken near Sioux City, and I drew on the blackboard with them the three sections which accompany the paper, and at the end I said, writing with that chalk, "Craie d'Amerique," that in order to prove the constancy of lithological characters on vast surfaces of the earth, I had used only *American white chalk* that evening for my communication before the Geological Society of France. All the members applauded loudly my practical remark.

In finishing my review of professor Hill's work, I must mention the excellent "Geological Map of southwestern Arkansas" at the scale of 1:202,752, which accompanies the volume. The legend comprises six divisions, beginning with the alluvium, then the plateau gravel, the Tertiary, upper Cretaceous, lower Cretaceous and Trinity divisions. So that according to professor Hill, the Trinity is not Cretaceous; then he ought to have used another color than green. It is the only criticism to be made of that beautiful map; the Trinity formation being Jurassic ought to be colored in pale sky blue, which would have improved the appearance of the map. The limits of the formations are very distinct, and the distribution of the Trinity division shows a break of some sort between it and the lower Cretaceous, which exists only at a single spot, at Cerro Gordo. In a country so wooded and unhealthy as southern Arkansas, explorations are very difficult and even dangerous on account of the malaria, and professor Hill has not an easy task.

On the whole, volume II of the Arkansas geological report for 1888 is a most creditable work, which reflects honor not only on its author, professor Robert T. Hill of the University of Texas, by far the best practical geologist who has ever

studied southern Arkansas and Texas, but also on professor John C. Branner, the state geologist. The State of Arkansas must be complimented to have secured the services of such able observers.

Cambridge, Mass., September, 1889.

FENCE WALL GEOLOGY.

By Aug. F. Foerste.

In drift covered areas actual exposures of bed rocks are often insufficient in number to determine even the simpler problems of geology. In such cases any assistance derived from other sources is often of value. In regions where the drift near its surface contains boulders sufficient in size and abundance for the construction of fence walls, these boulders will often furnish the desired data. Since such boulders are placed in fence walls as a rule in the most expeditious manner consistent with the clearing of the adjoining fields, they have usually been removed too short a distance from their position in the fields to seriously affect any investigation as to their distribution. Moreover, an examination of the neighboring topography, the slope of the lands, the presence of streams and ponds, and similar data, will frequently even make their original position in the fields quite certain. The existence of fence walls also implies the existence of boulders in sufficient numbers and of sufficient size to insure the observer that their original location, while a part of the bed rock, is not too far distant to make a study of their distribution profitable. The study of fence walls, therefore, becomes the study of the larger elements of the drift.

It is well known that near their source in the bed rocks the elements of the glacial drift are quite angular, but that owing to attrition the corners and edges are gradually blunted or worn off as their distance from the source increases, until finally the fragments become quite decidedly rounded. All this is of course accompanied by decrease in size. With a further increase of the distance from the original source the size of the boulders becomes too small even for use in fence walls, and the further increase of distance is therefore also noticed by the smaller percentage of such boulders *found* in the fence walls. This smaller percentage may also be due to another

cause. For while the greater percentage of boulders travel along the path of the glacier (or with its gradient) a considerable percentage deviate from this course; many 5, some 10, and a few even as much as 15 degrees, thus affecting the percentage of such boulders in the fence walls. Knowing the direction in which the glacial drift moved from the scratches it left on actual exposures of bed rocks, it is possible by means of an examination of the relative degree of angularity and size of rocks, the frequency of their occurrence in the fence walls, and a study of their distribution, to trace boulders back to their original source.

It is evident that the study of very angular bowlders is alone of direct value in determining the original position of any class of rocks, since these alone lie near their original source. A record of the remaining boulders of the fence-walls is, however, of value in determining their probable distance from the original source, and in guiding future search. When boulders are derived from rocks maintaining their lithological and palæontological characters over wide areas, the angular boulders derived from one locality within this area will be mingled with the more or less rounded boulders from some other locality in the same area, so that careful records are always of value in reaching accurate conclusions. Note-taking is chiefly confined to recording the varying percentage of the various rocks forming fence-walls and their degree of angularity. A record of their size, in addition to that usually already indirectly expressed in a record of their percentage, is usually of less importance.

The distribution of the very angular rocks will determine the form of the original area, whether the exposure was local and limited in all directions, formed a long narrow band, or covered a wide and extensive area. It will be of some assistance in this work to remember that the limits of any formation in going against the glacial gradient are near the line of more or less abrupt disappearance of all boulders derived from that area, and that the limits of the same area on the side with the gradient are best determined by the similarly sudden appearance of boulders of a *different* character. As the boundaries of any area approach parallelism with the glacial gradient, boulders of nearly the same degree of angularity but derived from different sides of the boundary will become inter-

mingled, so that in such cases the determination of the boundaries becomes more conjectural.

Studies based upon preceding principles having led to a rough delineation of the area formerly occupied by any class of rocks it becomes necessary to correllate this area as determined by boulders more closely with the area exposed by the bed-rocks during erosion. For this purpose recourse is had chiefly to topographical features.

The most common of these are differences of elevation between two adjacent areas geologically distinct, due to the frequency with which rocks of different geological ages show different degrees of resistance to the action of erosion. This is likely to result in the formation of single hills when the original area was a boss of some igneous rock; long, narrow broken ridges or valleys when the original area was long and narrow, whether sedimentary or igneous in origin; flattened or much diversified areas of greater extent but of marked difference in general elevation when the original areas were of considerable extent. In such cases the boundaries between neighboring formations are apt to be found nearer the base of the hills or the top of the sides of the valleys expressive of the variable resistance offered to erosion by the different geological formations.

Any abrupt change in the character of a rock, from a sandstone to a conglomerate, a shaly series, an igneous formation, and the like is a potential line of weakness. Owing to a variable degree of hardness and tenacity the rocks along such planes are apt to become separated during folding and a moderate amount of sliding or faulting may take place on these planes, and give rise to additional fractures along the plane of separation.—The difference of velocity with which rocks immediately on either side of such planes transmit earthquake shocks is also likely to find its expression in a general loosening of the strata along those planes, accompanied often by some sliding.—Ordinary faults in addition to a general plane of separation are often accompanied by minor fractures in the vicinity owing to friction during faulting. All of such fractures in whatever way caused are liable to intensify the differences of elevation at the boundaries of adjacent geological areas, by offering regions favorable for the cutting action of erosion, whether by ice or water; and such fractures usually

express themselves as beds of streams, long lakes, or valleys. In localities presenting great geological diversity and subjected to long erosion it is often found that the existence of a well marked valley, stream or pond, immediately heralds some change of formation which will be found on crossing the same. Boundaries of geological areas as determined by boulders are then readjusted also with reference to neighboring streams and valleys.

Where the rocks dip towards their boundaries, the boundary streams will usually be found to remain near the fractures which determined their course. Where they dip away from their boundaries, especially if composed of softer rocks, the streams will often wander a small distance from their original beds.—As a general rule the dip of rocks in the more recent formations is away from, in the older rocks, towards, any area of massive igneous rocks penetrating the same. This simply means that since such igneous rocks do not always show themselves at once at the surface, the element of time must be taken into consideration, and as a rule the anticlinals of any area are sufficiently eroded to expose igneous rocks not originally shown at the surface, before synclinals containing corresponding igneous rocks in the same position are sufficiently eroded to expose them. A certain allowance must be made for the probable change of course of any stream since its first connection with a series of fractures.

Such, in general, are the methods used in gaining some slight assistance from the boulders of fence walls and from topographical features when the drift is too heavy to permit the frequent exposure of the bed-rocks. Frequent modifications of these methods are used in the field, but the principles are all those well understood by the glacial geologist and do not need further discussion. The amount of information often obtained in this way would no doubt be a matter of great surprise to those geologists who neglect all features except surface exposures. Yet, since the value of all such work is dependent upon the accuracy and distinctness with which the original boundaries of bed-rocks, now drift-covered, can be traced, such methods find their best practical application where the dip of rocks is strong enough to furnish sharp boundaries along their strike (30° to 90°) where the structure

is complicated, but not upon a small scale. Actual exposures, though isolated, always furnish a check upon such work.

EDITORIAL COMMENT.

SOME RECENT SPECULATIONS ON THE ORIGIN OF PETROLEUM.

The distinguished Russian chemist Prof. Mendeleéf of St. Petersburgh, has recently discussed from a new standpoint this oft-mooted question and as considerable currency has been given to his theory, this fact, together with the eminence of its author as a chemist, renders some notice of it appropriate to these pages.

In his essay Prof. Mendeleéf sets out with the statement that most writers tacitly assume that petroleum is a product of vegetable matter. For this assumption there is, he says, no ground unless we admit that its chemical composition—resembling coal so closely as it does—may be admitted as an argument. This origin he sets himself to disprove. Petroleum could not, he says, have been produced on the surface because it would have evaporated. Nor could it have been produced over a sea-bottom because it would have floated up and have passed off. Thirdly, he maintains it must have been formed where it now exists, because it could not have been transported as sand or clay, and could not have flowed on the surface.

Now with all respect to the eminent attainments and brilliant reputation of Prof. Mendeleéf we may say at once that this catalogue does not by any means exhaust the list of possibilities. There are situations in which petroleum may have been made other than the surface and the sea-bottom. Indeed, we have never heard the former advocated by any one. And granting, for the sake of argument, that petroleum can not be transported very far, yet Prof. M. adduces no satisfactory evidence against its formation in the region in which it actually occurs.

We must assume that Prof. M. has some practical acquaintance with the geology of the Baku oil-regions of Russia but we can not refrain from suggesting that he does not show the familiarity with similar districts in North America that would

be desirable in one who undertakes to propound a new theory on so difficult a subject.

According to his statement the oil-bearing strata of Europe belong chiefly to the Tertiary or later ages. He therefore admits that the Carboniferous deposits beneath them may possibly be the source from which their oil has been derived. But he adds that the oil-bearing sands of North America belong to the Devonian or the Silurian strata in which few or no organic remains have been found. If the Coal Measures were the source of the oil it would never, says he, have gone down into the underlying Devonian rocks of Pennsylvania through the intermediate shales and clays, so that it is not possible to attribute its origin to the secular changes produced in coal by heat and pressure.

It seems incredible that such a statement can have been made by any one acquainted with the abounding fossils of these rocks in Canada and the United States, where whole layers consist in some places of almost nothing but the relics of bygone life, both animal and vegetable. This is the case with many beds in the Trenton and Hudson River groups. The Devonian rocks in the eastern and midland states are also filled with similar remains, especially of marine invertebrata and fishes, while some strata of this latter system in places consist of little save the minute sporanges of aquatic cryptogams, indicating an abundance of these plants at that date, which it is difficult to realize.

The prevalent opinion among geologists is that petroleum results from the slow secular changes that take place spontaneously, as it were, in such masses of organic matter as we have just indicated. Sea-weeds and plants of their low grade leave, in most cases, no distinct fossil remains, but their decay produces a quantity of bituminous material which may be represented merely by the black carbonaceous substance of the shales. It is only when, as in Ohio, such shales containing more or less bitumen in their mass are overlain by a porous sandstone and that in turn by an impervious layer of shale that the conditions are fulfilled and a store of gas or of oil results. A porous limestone may take the place of the sandstone and a bituminous limestone may play the part of the shale, as in northern Ohio, but the general conditions remain

unchanged so that there is in reality no need to look for any other source of petroleum.

Mr. W. Anderson, in his presidential address to the Section of Mechanics of the British Association at Newcastle-on-Tyne, developed to his audience Prof. Mendeleéf's theory, and apparently with approval. In his sketch, which is somewhat hypothetical, he follows his leader in presupposing as a necessary condition, the existence of iron in immense quantities in the interior of the earth, both pure and in the form of carbides. Water penetrating the crust is supposed to react on these substances and so to develop a hydrocarbon at the expense of its own oxygen. The new hydrocarbon thus produced is carried up with the steam into which the water has been transformed and deposited as soon as the cooler strata are reached.

It is scarcely necessary to mention that the data here assumed are not only unproved, but highly improbable. In fact their assumption almost amounts to a return to the old hypothesis of Sir Humphrey Davy, who, in his enthusiasm at having discovered the remarkable properties of potassium, imagined a vast storehouse of his new metal in the bowels of the earth, by the aid of which he could explain all the phenomena of volcanic action on chemical principles.

Prof. Mendeleéf further endeavors to support his theory by asserting that oil-bearing regions always lie near to or run parallel with mountain ranges, as in the case of the Appalachians and the Caucasus. In the synclinal cracks, widening below, which he says must exist in such regions, lie the accumulations of oil and gas. Now it is well known in America that a fissured region, especially a synclinal, is barren ground, and that a disturbed region is also devoid of oil and gas. Both occur only in strata almost horizontal and usually along lines of very slight anticlinal arching. So that geology affords no ground whatever for the new theory.

Moreover there are exceedingly productive districts in the western hemisphere, such as those in Indiana, in Ohio, and in Ontario where there can be no such fissuring as is required by Prof. Mendeleéf. The regions in question lie at a distance from all mountains and all disturbance capable of producing fissures and in the midst of a wide extent of nearly horizontal and uncontorted rocks not varying from the level more

than a few feet in a mile. All the chief data required for the new theory are conspicuously absent.

Finally Prof. Mendeleéf seems to depend largely for the support of his theory on the enormous quantities and high pressure and permanence of the oil and gas supplies. This he uses as a powerful argument against the belief in their derivation from any organic source, such as the bituminous shales of the Secondary or even of the Palæozoic rocks. This abundance indicates, he thinks, an origin in chemical action in the primary nucleus of the earth or in the deeper parts of the crust. This doctrine would be welcomed by all those whose money is in gas and oil and would be indeed joyful news to all who have hoped to be delivered from the plague of smoke by the advent of natural gas. But we can assure Prof. Mendeleéf that this last hope will prove fallacious, and that how abundant soever may be the present supply, that supply is destined to fail, and before very long. The new oil and gas region of the Caucasus may not yet show sign of failure, and years may pass before such sign appears, but the falling off of the spouting and flowing wells which is as constant there as elsewhere, and the need for pumping where the yield was once spontaneous, are indications that can not be mistaken; and as the great gushers of Pennsylvania have long since ceased to flow, so the enormous supplies elsewhere will one day follow suit.[1] Economy is the wise policy of all engaged in the manufacture, in order that the wonderful store of natural fuel, liquid and gaseous, may last as long as possible. Signs are abundant that the quantity is limited, and that if produced now at all the production is far slower than the consumption. Apprehension is already felt that the great blowers of gas at Pittsburg are running down and such announcements as the following are not calculated to allay the feeling.

"That the gas supply in this (Pittsburgh) district and adjoining places has passed its zenith and is now on the wane can no longer be satisfactorily denied. The reason usually given was that new mains were being laid to the wells or that the size of those already down was being enlarged. These changes have all been made and still the desired fuel does not pour through

[1] See an article on "The Future of Natural Gas" in the "American Geologist for January, 1888, where this state of things was distinctly foretold.

in the necessary quantities. This state of affairs was noticed first in the latter part of last winter, but the coming of warm weather relieved the pressure for domestic purposes and nothing was heard of the shortage during the summer months. But with the first appearance of a change of temperature this fall the trouble recommenced in an aggravated form. The last movement of the natural gas companies has been to ask the big mills to run only at night, when the demand for fuel for other purposes would be slight. Many of the establishments have decided to return to the use of coal and some have already done so."[2]—*Philadelphia Enquirer, Oct. 15, 1889.*

In the conclusion of this address Mr. Anderson remarks: "We are almost forced to the belief that the hydrocarbon products must be forming as fast as they are consumed, and there is little danger of the demand ever exceeding the supply, and that there is every prospect of oil being found in almost every portion of the surface of the earth, especially in the vicinity of great geological disturbances. Improved methods of boring wells will enable greater depths to be reached and it should be remembered that apart from the cost of sinking a deep well there is no extra expense in working at great depths, because the oil generally rises to the surface or near it. The extraordinary pressures, amounting to 300 pounds on the square inch, which have been measured in some wells, seem to me to yield conclusive evidence of the impermeability of the strata from which the oil has been forced up and tends to confirm the view that it must have been formed in regions far below any which could have contained organic remains."

After what we have already said it is needless to point out the fallacy of Mr. Anderson's reasoning and the baseless nature of the rose-colored vision with which he amused his audience

[2] We find that the same complaint comes from Wheeling, W. Va. In the issue of the Scientific American for October 5, which has just come to hand, we read, "The natural gas supply is becoming scarcer every day and there is especial complaint among the manufacturers who had hoped that during the warm weather they would have all the gas that they needed. For several weeks past the Riverside Tube Works and Plate Mill have been very greatly troubled by lack of gas and at times have been compelled to stop till the supply became better. The company is getting things into shape as rapidly as possible to go back to the use of coal in the tube works. The Bellaire mill has gone back to the use of coal and the Labelle is understood to contemplate a return to coal in all departments. Several other mills and factories are in the same position."—*Register.*

in the latter part of his discourse. No gas or oil well has ever been known to afford a pressure greater than that due to its depth, or indeed equal to it. No oil well has flowed except in diminishing quantity even for a few years, nor has the oil permanently reached the surface. Nor does the ability of reaching greater depths afford us any hope. Already the wells are far below all the productive strata. Three thousand and even four thousand feet have been penetrated and the ancient gneissic rocks have been reached in the United States, while in Germany even this has been surpassed and the augur has been down five thousand feet below the surface and the latest report gives the actual deepest boring at 5,735 feet, or considerably more than a mile. But the lowest oil-bearing strata in North America are only about 1,500 feet down, and it is rare indeed to find any valuable yield below that depth. In the Caucasus the beds are, we understand, even nearer to the surface. All analogy and all probability, are therefore, against the chance of our ever finding gaseous or liquid fuel at great depths in the crust and the idea of going down below the Palæozoic strata in search of oil or gas in the hope of winning them from the old Archæan rocks below can find no place in the mind of any one of sound judgment and practical experience in the subject, be he chemist, geologist or only well-sinker.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Address to the Geological Section of the British Association. By JAMES GEIKIE, LL.D., F.R.S., president of the Section. Newcastle-upon-Tyne, Sept. 12, 1889. pp. 27. (A reprint of this address, excepting its two introductory pages, is given in the Geological Magazine for October). The subject is the recent progress in glacial geology, with reference chiefly to the limits, and to the marginal moraines and other drift deposits, of the ice-sheet of northwestern Europe, together with its relation to the loess, to interglacial epochs, and to the antiquity of man.

Professor Geikie recounts the phases of opinion that have prevailed among German geologists concerning the origin of the drift. At first submergence and icebergs were appealed to as explaining everything; but since Dr. Otto Torell, in 1875, first stated his belief, that the "diluvium" of northern Germany was of glacial origin, ingenious attempts have been made to show that the drift was formed partly by floating-ice and partly by land-ice, until with extended

observation and study, the element of floating-ice has been gradually eliminated, and all the phenomena now find explanation by means of land-ice and "schmelz-wasser" alone, that is, by the ice-sheet and the water produced by its melting. The marine shells that are found rarely in the German stony clays, along with mammalian bones and fresh water shells, have been shown to be derivative in their origin, being just as much erratics as the stones and boulders with which they are associated.

Following the summary by Dr. Jentzsch of the present opinions of German geologists, the author notes that the northern regions, as the Scandinavian peninsula, Lapland and Finland, were the feeding-grounds of the ice-sheet. "In those regions melting was at a minimum, while the grinding action of the ice was not effective. * * * * Further south melting greatly increased, while ground moraine at the same time tended to accumulate, the conjoint action of glacier-ice and subglacial water resulting in the complex drifts of the peripheral area. In the disposition and appearance of the aqueous deposits of the 'diluvium' we have evidence of an extensive subglacial water circulation, glacier-mills that gave rise to 'giants' kettles,' chains of subglacial lakes in which fine clays gathered, streams and rivers that flowed in tunnels under the ice, and whose courses were paved with sand and gravel. * * * * The dove-tailing and interosculation of boulder-clay with aqueous deposits are explained by the relation of the ice to the surface over which it flowed. Throughout the peripheral area it did not rest so continuously upon the ground as was the case in the inner region of maximum erosion. In many places it was tunnelled by rapid streams and rivers, and here and there it arched over subglacial lakes, so that accumulation of ground moraine proceeded side by side with the formation of aqueous sediments. * * * * Now a study of the ground moraines of modern glaciers affords us a reasonable explanation of such differences. Dr. Brückner has shown that in many places the ground moraine of Alpine glaciers is included in the bottom of the ice itself. The ground moraine, he says, frequently appears as an ice-stratum abundantly impregnated with silt and rock-fragments,—it is like a conglomerate or breccia which has ice for its binding material. When this ground-moraine melts out of the ice—no running water being present—it forms a layer of unstratified silt or clay, with stones scattered irregularly through it. Such being the case in modern glaciers, we can hardly doubt that over the peripheral areas occupied by the old northern ice-sheet boulder-clay must frequently have been accumulated in the same way. Nay, when the ground-moraine melted out and dropped here and there into quietly flowing water, it might even acquire in part a bedded character." Professor Geikie also believes that the drifts of middle and southern England, which exhibit the same complexity, will eventually be generally acknowledged to have had a similar origin.

The interglacial beds of northern Germany contain remains of a well

marked temperate fauna and flora, which indicate, as the author thinks, more than a partial or local retreat of the ice-sheet. The geographic distribution of the beds and the presence in them of such forms as *Elephas antiquus*, *Cervus elaphus*, *C. megaceros*, and a flora comparable to that now existing, lead to the belief that the interglacial epoch was one of long duration and characterized by climatic conditions apparently not less temperate than those of the present time. Penck, Böhm, and Brückner find evidence of two interglacial epochs, and maintain that there have been three distinct and separate epochs of glaciation in the Alps. Others, however, as M. Falsan, the eminent French glacialist, do not believe in the existence of any interglacial epoch, although they readily admit that there were great advances and retreats of the ice during the glacial period.

Successive marginal moraines, the outermost lying, as in the upper part of the Mississippi basin, at a considerable distance north of the extreme limits reached by the ice-sheet, are traced across northern Germany, and (marking later stages of the glacial recession) around the southern coasts of Norway, across the province of Gottland in Sweden, passing through the lower ends of lakes Wener and Wetter, and in Finland from Hango Head, east-northeasterly, passing north of lake Ladoga.

The author believes that the loess is for the most part of aqueous origin, referring its deposition to the flood-waters of glacial times, spreading their fine sediment over wide regions of the low grounds, in the slack waters of the rivers and in temporary lakes. But he remarks that there are different kinds of loess or loess-like deposits, and that all need not have been formed in the same way. Probably some may have been derived, as Wahnschaffe has suggested, from the denudation of boulder-clay; and there are still other accumulations, as the berg-loess, with its abundant land shells, which no aqueous theory will satisfactorily explain. Such loess is apparently the result of subaerial action, of rain, frost, and wind acting upon the superficial formations.

Palæolithic implements, giving evidence of the early appearance of man in Europe, are found, as Prof. Geikie has long maintained, in beds of glacial and interglacial age; and he believes that none of these, but only neolithic implements, showing increased skill in their manufacture, occur there in postglacial deposits.

This address closes with the suggestion that when the conditions of the glacial period and the causes that gave rise to these have been more fully and definitely ascertained, we shall have advanced some way toward the better understanding of the climatic conditions of still earlier periods, the problem being stated as follows:—"One of the chief factors in the present distribution of atmospheric temperature and pressure is doubtless the relative position of the great land-and water-areas; and if this be true of the present, it must be true also of the past. It would almost seem then as if all one had to do to

ascertain the climatic conditions of any particular period was to prepare a map depicting with some approach to accuracy the former relative position of land and sea. With such a map could our meteorologists infer what the climatic conditions must have been? Yes, provided we could assure them that in other respects the physical conditions did not differ from the present. Now there is no period in the past history of our globe the geographical conditions of which are better known than the Pleistocene. And yet when we have indicated these upon a map, we find that they do not give the results which we might have expected. The climatic conditions which they seem to imply are not such as we know did actually obtain. It is obvious, therefore, that some additional and perhaps exceptional factor was at work to produce the recognized results. What was this disturbing element, and have we any evidence of its interference with the operation of the normal agents of climatic change in earlier periods of the world's history? * * * * The success with which other problems have been attacked by geologists forbids us to doubt that ere long we shall have done much to dispel some of the mystery which still envelops the question of geological climates."

Solar heat, Gravitation and Sun-spots. J. H. Kedzie.[1] Two hundred and seventy-eight years ago dark spots were first discovered on the sun, and they have been the source of much discussion and research. Sometimes they are so large that they can be seen by the naked eye, covering millions and even billions of square miles. They frequent two belts on the sun's surface equi-distant from the equator, fading out along either edge. These belts of maximum frequency extend from ten degrees either side to about thirty degrees north and south from the equator. They increase and diminish in frequency at nearly regular periods of about eleven years. When they appear at the edge of the sun's disc their perspective clearly shows that they "are immense chasms in the strata of the photospheric and penumbral clouds, laying bare for the time the inner, darker and cooler nucleus of the sun." They are exceedingly variable in size and duration —the latter varying from a few hours to weeks or months.

As already stated, the interest of the book culminates in the discussion of these spots, and in the application the author makes of his general theory to their explanation. A few more ascertained facts respecting the nature of the sun's photosphere and these spots will serve as an introduction to this explanation, viz: It has been determined by actual experiment that the umbra emits fifty-four per cent. and the penumbra about eighty per cent. as much heat as a corresponding part of the photosphere. This shows that the heat of the photosphere is not derived from the interior of the sun, and consequently must come from without, from a supply independent of the internal heat of the sun. 2nd. The lightest portions of the photosphere are the hottest. The faculæ, "the sun's Himalayan mountains of light" are

[1] For other portions of this review see pp. 181, 246 and 300.

the most dazzlingly white, and the hottest. 3rd. If the sun had no external source of supply of heat it would only be a question of time, and according to the best authorities a brief time at that, when the sun would be so far cooled down as to render the earth uninhabitable.[2] 4th. The heat of the photosphere is so intense that chemical affinity is suspended, or abrogated, and the elements exist, all or nearly all, in the condition of gases, descending gently or floating in flocculent clouds of fire throughout the whóle expanded atmosphere.

In the light of these considerations, and by resort to the theory of light and heat which has been presented, the reader will quickly apprehend the use the author makes of the sun's spots not only to further elucidate his general theory, but to offer a new theory of their cause.

The spots are cooled places on the sun's photosphere. They are shadows, not of intercepted light, but of force-waves of the surrounding ether. They are "spells of weather" produced by similar causes as those of our atmosphere, viz.: variations of temperature in the enveloping atmosphere and clouds.

It is incumbent on the author to furnish a plausible cause for such shadows. He attributes them to Jupiter and the other planets. They intercept waves of mechanical force, or gravitation, carried by the undulations of the ether, and produce about the sun's equator a deficiency of energy in the photosphere. The sun's poles are hotter than his equator.

In order to show that this suggestion is plausible some arguments are drawn from the unequal rotation of the spots across the sun's disc. That is, since the equator is cooler than the poles there must be a circulation in the sun's envelop similar to that of the earth's atmosphere. Consequently those spots that appear at the greatest distance from the equator will show the "lagging behind" or the accelerated rate which the circulating tides and the winds of the earth show in making their regular courses from north to south, or *vice versa*. But the fact that the spots are most numerous in two equatorial belts is handled so convincingly that it proves one of the strongest arguments in favor of the author's theory. The average inclination of the planets' orbits to the axis of the sun is less than thirty degrees. They therefore concentrate their force of interception upon the equatorial regions, and this appears in two belts of maximum frequency of spots, each fading out toward the equator, because at the equator the downpour of the cooled elements toward the nucleus causes the spots to disappear in their deeper seated journey back to the poles, and the more heated superficial strata rush in to take their place. The sun's equatorial region is therefore, like that of the earth, one of greater atmospheric commotion, with occasionally "cyclonic" spots.

The periodicity of the maxima of sun-spots is made to throw further evidence on the interception theory of their cause. It is found that

[2] Newcomb's "Popular Astronomy." p. 518.

there is an approximate agreement between the perihelia of Jupiter and these maxima. Those instances in which the agreement is not so close are supposed to be due, when not referable to inexact or insufficient observation, to the greater concentration of the perihelion influence of some of the other planets at somewhat different periods.

In conclusion, while it is possible to point out difficulties in accepting the author's views, and his application of them to some of the facts, there is much that is original and striking in this work, and it can not but play an important part in ultimately bringing the science of astronomical physics into consistent accord with acceptable doctrines of the nature and action and origin of the sun's heat. We commend the book earnestly to all students of the celestial mechanics.

RECENT PUBLICATIONS.

1. *State and government reports.*

A dictionary of the fossils of Pennsylvania and neighboring states named in the reports and catalogues of the survey. J. P. Lesley. 3,000 figures, mostly facsimile copies, and some new species drawn and described by G. B. Simpson. Harrisburg, 1889. pp. 437, and xxxi (of errata for vol. i.) vol. i, A to M. *Second Geol. Sur. Penn.* P4.

2. *Proceedings of scientific societies.*

Journal of the Elisha Mitchell Scientific Society, vol. iv, Part i, 1889; contains historical notes concerning the North Carolina geological survey. By Prof. J. A. Holmes.

Journal of the Cincinnati Society of Natural History, vol. xii, Nos. 2 and 3, Oct. 1889; contains Devonian plants from Ohio. J. S. Newberry. Fort Ancient. By Warren K. Moorhead.

3. *Papers in scientific journals.*

Am. Jour. Sci., Nov. No. Mathematical theories of the earth. R. S. Woodward. Observations on some of the trap ridges of the East Haven-Branford region, with a map (Plate ix). E. O. Hovey. Theory of the mica group. F. W. Clarke. Probable law of densities of the planetary bodies. R. Hooke. Pseudomorphs of native copper after azurite from Grant county, New Mexico. W. S. Yeates.

4. *Excerpts and individual publications.*

On the San Emigdio meteorite. Geo. P. Merrill. (One plate). *Proc. U. S. Nat. Museum,* 1888. p. 61.

On a peridotite from Little Deer isle, in Penobscot bay, Maine. Geo. P. Merrill. (One plate). *Proc. U. S. Nat. Mus.* 1888. p. 191.

Missouri; its mineral resources. G. C. Broadhead. *Rep. Com. Stat. U. S.,* for 1889. p. 461.

The aborigines of the district of Columbia and the Lower Potomac, a symposium. By Otis T. Mason, W. J. McGee, Thomas Wilson, S. V. Proudfit, W. H. Holmes, Elmer R. Reynolds and James Mooney. From the *American Anthropologist.* Vol ii, No. 3. 1889.

CORRESPONDENCE.

THE CHEMICAL ORIGIN OF THE VERMILION LAKE IRON ORES. In an article which is published in the November number—On a Possible Chemical Origin of the Iron Ores of the Keewatin in Minnesota, by N. H. Winchell and H. V. Winchell—the statement of opinions, as held by the late professor Irving and myself are so different from our true views that I ask that you insert in your next number the following:

On page 291 the article says:

"It is evident that the papers of the late Prof. R. D. Irving and of Prof. C. R. Van Hise, while in the main considering the problem from the point of view of the "Huronian," have also embraced in the scope of the phenomena cited, a group of strata much older, which lie everywhere unconformably under the Huronian, and which present a series of facts which are distinct from those appertaining to the Huronian as found in the Penokee-Gogebic and Mesabi regions. The confounding of two formations, and the placing in one category the chemical and structural phenomena that are separated into two series by a great time interval, and by structural unconformity, have so complicated the problem that hitherto no theory has been found capable of covering all the facts. The existence of this widespread unconformity has been shown in recent reports on the geology of the northwest, by A. C. Lawson, A. Winchell, and by the writers; and latterly it was also recognized by Irving (7th An. Rep. U. S. Geol. Sur.)"

As a matter of fact professor Irving recognized this unconformity as early as 1881. This is perfectly evident by his six generalized geological sections of the lake Superior basin, (Copper-Bearing Rocks of Lake Superior, page 416), in all of which the Animikie rocks are placed in unconformity above the gneisses and schists. Also in the November number of the American Journal of Science for 1887, page 261, professor Irving describes in detail an unconformity between the Animikie beds in Gunflint lake and the underlying schists. This is the locality described by professor Alexander Winchell of the Minnesota Survey several months later (Volume I, No. 1 of the AMERICAN GEOLOGIST, pp. 14-24).

The article assumes that the schists referred to above as occurring unconformably below the Animikie are the same as the rocks which bear the iron ores in and about Tower and Ely, Minn. This is taking as settled the very question at issue. To call the rocks below the Animikie, Keewatin, and the rocks which bear the Vermilion lake iron ores, Keewatin, is no evidence of equivalence. It was professor Irving's opinion that these formations are not equivalent; and that the Animikie series and that bearing the Vermilion lake ores are equivalent. The reasons for this opinion can not be given here, but reference is made to his elaborate discussion of the whole question in the 7th Annual Report of the U. S. Geological Survey.

On page 294 of the article in the AMERICAN GEOLOGIST is said:

"The difficulties in applying the theory of Irving, i. e. the metasomatic substitution of oxides of iron for some pre-existing carbonate,

appear when we search for the remains of the supposed older carbonate, and when we find the country rock does not afford good reason to have expected the deposition of any carbonate; and also when we search for the remaining ingredients which the assumed metasomatic process may have left in the ore."

This implies that no carbonate of iron is found associated with the iron ores of Vermilion lake. This is not the case. Professor Irving found as early as 1885 finely laminated rocks which bear a large percentage of iron carbonate immediately adjacent to the iron ores which occur near Tower. Indeed, in his article on the origin of the iron ores in the American Journal of Science, he particularly emphasizes the fact of the presence of iron carbonate in these Vermilion lake ores, and in some detail describes the changes to which the rock has been subject. Among other facts is mentioned the formation of iron oxides pseudomorphous after iron carbonate. Analysis by professor W. W. Daniells shows that the amount of iron carbonate in one specimen collected by professor Irving in the summer of 1885 is as high as 25 per cent. It was such facts as this, combined with many other points of similarity between the Vermilion lake iron-bearing beds and the other important lake Superior iron-bearing horizons, upon which he based his argument for a like genesis of them.

The article in the AMERICAN GEOLOGIST also implies that I have maintained an origin for the ores of Vermilion lake like that of the Penokee-Gogebic country. I have refrained from expressing an opinion upon that question. I only say in the American Journal for January, 1889, "that it would be an interesting illustration of the uniformity of Nature's processes, if future investigations should show that the iron ores in the other regions of the lake Superior country have an origin like those of the Penokee-Gogebic series."

It is not my purpose here to discuss the opinions expressed by the authors in the paper, but merely to correct the misconceptions which are contained in the paper as to the work and opinions of the late professor Irving.

C. R. VANHISE.

Madison, Wis., Nov. 9, 1889.

Prof. Van Hise calls attention to the fact of the recognition by Prof. Irving of the unconformity between the Animike and the underlying gneisses and schists in the vicinity of Gunflint lake, and refers to Prof. Irving's general sections of the lake Superior basin (Copper-bearing rocks of lake Superior, p. 416), and to his descriptions in the *Am. Jour. Sci.* for 1887, p. 261. Prof. Van Hise quotes these as evidence that the statements made in the November GEOLOGIST,[1] to the effect that Prof. Irving did not recognize the two great iron-bearing horizons in the northwest and in his attempts to account for the existence of

[1] On a possible chemical origin of the iron ores of the Keewatin in northeastern Minnesota. p. 291.

the iron ore confounded them in one consideration, and covered them both by the same hypothesis, are incorrect.

Prof. Van Hise is very unfortunate in referring to the general sections made of the lake Superior basin by Prof. Irving and published in *Copper-bearing rocks of lake Superior*. Not only is there no evidence in the sections themselves that Prof. Irving recognized the unconformity which the article he criticises refers to, but, taken with the text, and in connection with the diagram on p. 417 of the same work, they confirm unquestionably the statements made by us in the November GEOLOGIST. In the first place the sections represent "gneiss, granite, etc.," as lying unconformably below the Animike, not "gneiss and schists," and throughout the volume he describes these as a part of the Laurentian. There is at no place in the volume, so far as we can ascertain, any reference to the great Keewatin formation—the green schists that enclose the Vermilion lake iron ores—which we state are also unconformable beneath the Animike. In the next place if we examine the diagram given by Prof. Irving on p. 417 of the same volume we see at once that the unconformity of which we speak was wholly unknown to Prof. Irving at that time, for this diagram represents the Huronian "unfolded" as continuous northward and becoming the "Folded Huronian," and involved there with crumpled Laurentian in some such way as to constitute what has been separated from the Huronian under the name Keewatin. At the foot of the same page Prof. Irving shows that he had not apprehended the distinctness of these schists from the Huronian, by the following statement: "The connection of these folded beds with the unfolded is a structural problem still needing investigation."

Prof. Van Hise is almost equally unfortunate in referring to the paper of Prof. Irving in the *Am. Jour. Sci.* vol. XXXIV, p. 261; for the schists that Prof. Irving there refers to are not admitted by him, (nor either are they by Prof. Van Hise) to be iron-bearing, and continuous to Vermilion lake. It is true that the non-conformity that is represented by Prof. Irving at Gunflint lake,[2] between the Animike and the lower schists and granites, actually does exist. It is also true that the same overlap of the Animike is to be seen on later schists, at points further west in the direction of the strike of the lower schists, and that these slightly higher schists embrace the ores at Vermilion lake. This unconformity at these western points, and its identity with that at Gunflint lake, was not admitted by Irving—nor is it yet by Van Hise—and therein is the complication and confusion that has arisen in attempting to apply the same theory for the origin of the iron ores to both formations, as represented in the article which is criticised by Prof. Van Hise. This lower horizon of schists has been traced carefully and

[2] This unconformity was described briefly in the same number of the *Am. Jour. Sci.* by A. Winchell, of the Minnesota Survey. It had been first noted by N. H. Winchell in 1878. See the ninth report of the Minnesota survey, pp. 10 and 82; also compare Bulletin No. 1, of the Minnesota survey, p. 33; and the seventeenth report, p. 15.

continuously between Vermilion lake and Gunflint lake and the points of unconformity with the overlying Animike have been mentioned in several places in the reports of the Minnesota survey.[3] There is no geological fact in connection with the work of the Minnesota survey on the crystalline rocks which is more confidently affirmed, or attested by more recorded facts of observation than that of the continuance of the Keewatin from Vermilion lake to the north side of Gunflint lake, and the unconformity of the Animike with the Keewatin at all places where the two formations can be compared. That it is the Keewatin, and not the Animike that holds the ore at Tower, this is no place to inquire. The reports of the Minnesota survey attest that conclusion in many places. If the facts stated in the Minnesota reports be not sufficient "evidence of equivalence" of the formations at these two points to satisfy Prof. Van Hise, we shall have to abandon the effort to do so. The hypothesis of Prof. Irving that some portion of the Animike has got entangled with the older schists at a point (at Tower) twenty miles distant from its known line of strike south of the Giant's range, and that the Animike once was continuous over the Giant's range to that point, is, so far as we know, the only evidence (if it may be so classed) of the Animike age of the Tower rocks. Prof. Irving's mistake consisted in having supposed the differences in crystalline structure that he noticed between two sets of rock samples from the Vermilion lake region (viz. some from the true crystalline schists and some from the Keewatin, or semi-crystalline schists) were the analogues of the differences he noted between two other sets of rock samples from the Marquette region (viz. some from the dioritic schists and greenstones and some from the iron-bearing fragmental Huronian); whereas these differences themselves are not only not of the same class, and are due to different causes, but the compared formations from which the samples were derived, do not occupy the same stratigraphic position.

Prof. Van Hise's reference to Prof. Irving's description of carbonate of iron in the Vermilion ore constitutes an important correction of our paper. We had not observed the fact reported by Irving. It ought to be taken into account in further research on this subject. We have referred to and read carefully the whole discussion of this carbonate in the Tower ore by Prof. Irving,[4] and it bears to us internal evidence that there was possibly some confusion in the labeling of the specimens from Minnesota, and that the carbonate and the "actinolitic magnetite slates" containing so much carbonaceous matter were not from the vicinity of Tower, but from the Animike at some points on the Mesabi iron range. We have never found such in the region of Tower, nor at any place in the Keewatin formation, but they are a

[3] Compare the 16th report Minnesota survey, pp. 67-71, 79, 80, 235, 255-259, 323, 357-359; seventeenth report, pp. 87, 88, 91, 104, 108, 110, 186.

[4] *Am. Jour. Sci.* vol. XXXII, 1886, p. 269.

characteristic of the Animike iron-bearing rocks of the Mesabi range. That there is sideritic iron in the Vermilion range we do not question. It is found in breccias and veins, but it is of secondary origin and not a primary constituent. It is found in large crystals in company with vitreous quartz, pyrite and coarse micaceous hematite.

N. H. WINCHELL AND H. V. WINCHELL.

Minneapolis, Nov. 17, 1889.

GILSONITE OR UINTAITE. This mineral was discovered by S. H. GILSON of Salt Lake and has ever since borne the local name of Gilsonite. The first description, however, was published in a paper by Prof. W. P. Blake in the Engineering and Mining Journal of Dec. 26, 1885, under the name of Uintahite.[1] He said:

"It breaks with a conchoidal fracture, is very brittle, and has a hardness of 2 to 2.5, with a sp. gravity of 1.065 to 1.07. It is black, brilliant and lustrous, with a rich brown streak, fuses easily in the flame of a candle, and has considerable plasticity when warm. It dissolves in the heavy oils and fats and in warm oil of turpentine. Ether dissolves it in powder. It also dissolves in melted wax forming a compound resembling ozokerite. It is more fusible than Albertite and Grahamite, heavier than Piauzite and contains less oil and gas than Wolongonzite."

The following analysis is reported in the same paper:

Carbon	78.43
Hydrogen	10.20
Nitrogen	2.27
Oxygen	8.70
Ash	.40
	100.00

With the added report on solubility—Bisulphide of carbon and chloroform dissolve it completely; benzole dissolves 95 per cent.; ether 86.5 per cent. and absolute alcohol 9.5 per cent."

Spirit of turpentine, it is said, appears to be the best commercial solvent of this mineral.

The Gilsonite or Uintaite occurs near Fort Duchesne and the line of the Uinta & Uncompahgre Indian reservations. It occurs in a vein about 5 feet thick, with smooth sides traversing sandstone. The vein has been followed for about two miles and traced downward about one hundred feet still retaining its full thickness. The upper twenty feet are somewhat comminuted by the weather, but not apparently altered in quality.

It seems likely from other reports that there are other seams of the same or a very similar mineral in the neighborhood of the vein above described, and a company has been formed to work it in the hope that it will be suitable for the various purposes for which asphalt is now in demand, especially for paving. Thus far it has been used for the man-

ufacture of black varnishes, for which purpose a large quantity was last year sent to Europe.

Akron, O., Nov. 1, 1889. E. W. Claypole.

The Geology of the Montmorenci. A correction in a date. The main object of the present note is to correct an error in dates as given at the head of an article as below. In the number of the Geologist for August, 1888 (vol. ii, pp. 94-100), is a reprint of an article by Dr. Emmons on the "Geology of the Montmorenci." It is stated to be taken from the American Magazine, November, 1847." This date is wrong. It should be *1841*. The article is in volume one of the above periodical, pp. 146-150. No notice seems to have been taken of this error in dates, but it was called to my attention when fortunate enough to see the original paper, which, by the way, I was a long time in doing, because of the very error alluded to.

There were only two volumes of the "American Magazine" published, and these cover the years 1841 and 1842. In the second volume, pp. 5-9, Dr. Emmons published another article in which he gives in detail the lithological features of the Hudson River rocks as seen on lake Champlain. He mentions their extent from Canada to Mexico and discusses the dislocation and change of position they have undergone. He also discusses the period at which the dislocation took place, and illustrates his remarks by two diagrams. In one of these he shows a fault on lake Champlain with the Trenton lower than the Calciferous. In the other the Hudson shales abut against rocks of Lower Helderberg age, namely, the Delthyris shale, Pentamerus limestone and Manlius waterlime.

Washington, D. C., Nov. 19, 1889. Joseph F. James.

PERSONAL AND SCIENTIFIC NEWS.

At the meeting of the Boston Society of Natural History, Nov. 6th, a communication from Prof. G. Frederick Wright stated the details of the finding of a small image at the depth of 320 feet in boring an artesian well at Nampa, in southwestern Idaho, about August 1st, 1889, with correspondence relating thereto. The image, which is about one and a half inches long, representing the human form, is made of baked clay, being identical in composition with the "clay balls," small lumps of irregular shape, that were found a little higher in the boring. It is a clay that has resulted from the decay of volcanic rocks, and in both cases it encloses microscopic particles of obsidian. The same kind of sand also is cemented on the surfaces of both by a slight incrustation of iron rust. The strata penetrated by the well are reported by Mr. M. A. Kurtz, who had charge of the work, as follows, in descending order:—soil and sand, 60 feet; lava-rock, 12 to 15

feet; quicksand, 100 feet; clay, 6 inches; quicksand, 40 feet; clay, 6 feet; quicksand, 30 feet; clay, 12 to 15 feet, at depth of about 250 to 265 feet; then, "clay balls mixed with sand," underlain by "coarse sand in which the image came up," and next "vegetable soil," resting on "sandstone." The well was bored at Nampa station, on a line of railway, about twenty miles southwest of Boisé City; the elevation of Nampa being about 2,500 feet above the sea, and that of Boisé City about 2,875 feet. The image came into Prof. Wright's possession through the courtesy of Mr. Cumming, general manager of the Union Pacific lines in that district, and of Mr. Charles Francis Adams, president of the Union Pacific railway company, both of whom were at Nampa shortly after it was found.

A letter from Mr. S. F. Emmons, of the U. S. Geological Survey, in response to inquiry concerning the geologic position of the beds penetrated at Nampa, states his belief that they belong to the Pleistocene, but are probably older than the gravel and sand beds in which human implements or other traces of man's presence have been found elsewhere in the United States, excepting, perhaps, in California.

THE NAMPA IMAGE.

In the discussion following this paper, Profs. Putnam, Haynes, and Morse stated their opinions that the image appears to be genuine, its condition and character being in keeping with the reported details of its discovery. Professor Cope spoke of his exploration of the fossil vertebrate faunas of that region, which would indicate for the Nampa beds a Pliocene or Pleistocene age. Mr. Upham suggested that these beds, excepting the lava, may be referable to fluvial action during the glacial and postglacial periods, perhaps, therefore, being no older than the modified drift in which palæoliths have been found in New Jersey, Ohio, Indiana, and Minnesota; and Dr. Fewkes remarked upon the Quaternary and even very recent age of various lava-flows in the western United States although at the present time no active volcano exists there.

THE KANSAS ACADEMY OF SCIENCE, held its annual session at Wichita, on the 24th, 25th and 26th of October, 1889. The pro-

gramme contained a long list of papers on various subjects. In Entomology, the paper of Prof. Snow, of the State University on the propagation of a fungoidal disease amongst chinch bugs, and the wide spread destruction of the pests apparently resulting therefrom, elicited considerable discussion in which Dr. Kellerman and Prof. Popenoe of the State Agricultural College, took part. Future seasons will have to determine whether this year's results, are general, or owing to special conditions. In electricity professor Blake outlined the principle of a micro-telephonic apparatus, by which sound signals may be conveyed under water to ships at sea or from ship to ship at a distance of upwards of two miles. In other departments of science many papers of more than technical interest were read but in geology the papers were few, though several on minerals and mining attracted much attention. Hon. J. R. Mead of Wichita had an interesting account of placer gold-mining in Montana and Dr. Newton of Oswego, sent a paper on some glacial (?) striæ in southern Kansas which places on record some valuable observations even though its conclusions be not taken without reservation. Prof. Cragin had some titles of interest on the Comanche Cretaceous, etc. but owing to his late arrival the papers were not read. Prof. Hay, who has recently been investigating several groups of artesian wells with special reference to their availability for irrigation, had a paper on the causes of the flow of these wells. While attributing most of them to the ordinary cause of artesian wells, the writer gave examples in which the column of water is held up to the point of overflow by inflow of gas. Others were given in which the flow of the wells, which is in each case small and the depth considerable, was attributed to *rock pressure*, rather than to gas or hydrostatic pressure. The last day of the session was given to an excursion to Kingman, forty-five miles west of Wichita where salt-making processes were examined at three plants, and the salt mine was visited, though, owing to temporary disarrangement of the machinery, no one could descend; yet the party secured abundance of specimens of the rock salt which has been brought from an eleven foot vein at a depth of 800 feet. The entire session of the Academy was a success, not the least successful part being the public lecture on the chemical components of the human body by the president, Prof. D. H. Dinsmore of the State Normal College. Prof. Failyer of the Agricultural College is the president elect.

THE IRRIGATION PROBLEM IN DAKOTA has been the subject of a review by Prof. Culver, of the Dakota University. Two plans were considered, that of artesian wells and that of a system of canals fed by the Missouri river. It appears that large areas in South Dakota can be irrigated by artesian water. The Sioux quartzyte, that underlies Union, Clay, Lincoln,

Turner, Yankton, Hutchinson, Hanson, McCook, Minnehaha, Moody and Lake counties, would probably prevent this plan in that part of the state. The first artesian well was obtained in 1884. Since then more than 100 successful wells, scattered through thirty or more counties, have been sunk, showing the wide extent over which the favorable conditions are known to exist. These wells give pressures varying from 5 to 170 pounds to the square inch, and flow from 4 to 4,000 or 5,000 gallons per minute. Making a careful calculation of the needs of the country, and balancing loss and gain from different unknown or uncertain causes of variation, Prof. Culver reaches the conclusion that three wells per township, each flowing an average of 3,150 gallons per minute, and costing each from $1,000 to $1,500, would supply water sufficient for all agricultural purposes. He also thinks the geological and topographical conditions are favorable for such a plan. The second plan is nothing less than a proposition to divert a part of the Missouri river, via Fort Stevenson, on the southern border of Stevens county, through the narrowest part of the coteau, across North Dakota, east by north, carrying it south of Devil's lake, thence eastward and southward, skirting the west flank of the Coteau de Prairie, emptying partly into the Souris valley, partly into the Red river of the North and partly into the James river, and by numerous irrigating canals to so disseminate it as to make it water all the country into which it can be carried. This is a feasible and comprehensive plan the chief obstacle to which is its costliness. It might interfere with the navigability of the Missouri at some lower points, but it is evident that the rights of irrigation are anterior and superior to those of navigation. Commerce can subsist only in countries that are habitable and productive.

Report of the committee on the international congress of geologists. Since the last meeting of the A.A.A.S. the London Congress has been held, at which a fair representation of American geologists was present. The reports of the American Committee having been approved by the unanimous vote of Section E at the New York meeting of the A.A.A.S. were, with a few additions (not obtainable for that meeting but unanimously approved by the committee) presented to the Congress and distributed among its members.

Mr. Topley, the general secretary, ordered a large edition of the American volume, with pagination altered to suit the needs of the volume of the Congress which he was editing.

It has been decided to issue the geological map of Europe in installments of one or more of the sheets at a time, instead of waiting until the whole map is complete, and this has rendered it necessary to make special arrangements for the delivery of these sheets to the American subscribers who now number the one hundred required to make up the sum paid by the

"large countries." Unfortunately the undersigned have not received any response to the letters addressed to Mr. Hauchecorne of the executive committee on the map, and are therefore unable to propose a plan of distribution.

The London Congress decided that the next session should be held in Philadelphia, Pennsylvania, United States, and appointed a provisional committee to take such action as might appear best to provide for the session. This committee appointed a larger committee, of which Dr. Newberry is chairman.

Your committee reports progress and asks to be continued.

JAMES HALL, Chairman,
PERSIFOR FRAZER, Secretary.

This report was adopted and the committee was continued.

THE SECOND ANNUAL MEETING of the Western Society of Naturalists was held at Madison, Wis., Oct. 23rd and 24th. President T. C. Chamberlin gave an evening address on "The method of multiple working hypotheses." Much of the time of the meeting was given to a discussion of methods in investigation and instruction and the exhibition of apparatus. Profs. Barnes and Van Hise discussed laboratory microscopes and petrographic methods. Profs. Arthur, Bessey, Salisbury, McMillan and Birge carried on an interesting and profitable discussion of "Laboratory facilities in vegetable physiology," and "What to do with a beginner in botany." There was an exhibition of the Newton and Wright electric projecting microscope. Profs. Birge, Nachtrieb and Barnes read papers on "Elementary bacteriology in college courses," "Taking of food by certain protozoa, especially Paramœcium," and "Recent methods in histology and embryology."

The Society adopted a resolution urging the free importation of scientific books and apparatus.

The following officers were elected for the ensuing year: Prof. C. E. Bessey, Lincoln, president; Dr. E. A. Birge, Madison, vice-president; Dr. J. S. Kingsley, Lincoln, secretary; Dr. Stanley Coulter, Lafayette, treasurer; the time for the annual meeting was changed to November and the next will be held at Lafayette, Ind.

IN THE JULY NUMBER OF THE AMERICAN GEOLOGIST mention was made of the finding of the teeth of a mastodon by Dr. Stephen Bowers in Ventura, California. The doctor refers them to *Mastodon shephardi*. He also discovered what he believes to be the remains of the large llama, *Holomeniscus californicus*. He also reports *Equus occidentalis* from that locality, and remains of a large seal, *Eumetoppias stelleri*. Of the latter he found the skull, teeth, vertebra and other bones. Also the remains of whales, the vertebræ measuring a foot in diameter. The most numerous remains of the whale are those of *Escrichtius davidsoni*. He has also found the

teeth of *Carcharodon rectus* somewhat numerous, while invertebrates have been collected in Ventura county in great abundance. It is a rich field for the geologist, and has an important bearing on the physical history of California, and of the Pacific slope.

MR. R. G. MCCONNELL, OF THE CANADIAN GEOLOGICAL SURVEY, has returned from his inspection of the region between the Peace and Athabasca rivers. He commenced about 300 miles north of Calgary and extended his operations for some 300 miles further north to the vicinity of Vermilion. The region embraces an area of 30,000 or 40,000 square miles. Little of this tract was ever explored before by white men. A great deal of it is good farming land, but swamps abound and make it unfit for settlement. The trees are principally spruce and poplar. Speaking of the deposits of oil reported to be there, Mr. McConnell said he certainly found quantities of tar, indicating the presence of oil, but just in what quantities it existed he was not prepared to say before making his reports.

PROF. ARTHUR WINSLOW, STATE GEOLOGIST OF MISSOURI, has entered upon the active prosecution of the survey. His headquarters will be at Jefferson City. He has made the following selections for assistants: James D. Robertson, Washington University, St. Louis, assistant geologist; Dr. Hambach, Washington University, St. Louis, assistant palæontologist; Elston Lonsdale, Columbia, aid to the palæontologist; Leo Gluck, Lamonte, aid and mining engineer; Prof. Walter P. Jenney, of the U. S. Geol. Survey has been assigned work in surveying the lead and zinc deposits in co-operation with Prof. Robertson.

ARTESIAN WATER FROM THE ARCHEAN. Operations of the Minnesota Iron Company at Tower, Minn., in sinking diamond drills into the Keewatin rocks to determine the position and extent of the ore deposits, have resulted in producing artesian or flowing wells in several instances. The water is pure and cold, and flows at the rate of three gallons per minute from the depth sometimes of over five hundred feet in the oblique direction of the drill, or about two hundred and fifty feet perpendicular depth. It is found to be useful and valuable at the mines.

PROFESSOR DANIEL KIRKWOOD, FOR MANY YEARS A PROFESSOR of astronomy in the Indiana State University at Bloomington, has removed his residence to near Riverside, in southern California.

DR. LEO LESQUEREUX, THE EMINENT PALÆOBOTANIST, DIED at Columbus, O., Friday, October 25th, in his eighty-third year. In a subsequent number of the GEOLOGIST will be given an appropriate sketch of his life and work.

INDEX TO VOL. IV.

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ERRATA.

p. 223, three lines from bottom, for "west of Pecos" read *east of Pecos.*
p. 233, eight lines from bottom of page, instead of "before" read *after*; instead of "S E." read *N. W.*
p. 94, vol. III. The date of publication of the article of Emmons was 1841, instead 1847.

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.Y, 1889. VOL. IV, No. 1.

11,990 -
July 2, 1889.

THE AMERICAN GEOLOGIST.

A MONTHLY JOURNAL OF

GEOLOGY AND ALLIED SCIENCES.

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GUST, 1889. VOL. IV. No. 2.

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11,990
Aug. 2, 1889.

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TOBER, 1889. VOL. IV, No. 4.

11,990
Oct. 14, 1889.

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VEMBER, 1889. 32,3. VOL. IV, No. 5.

THE AMERICAN GEOLOGIST.

A MONTHLY JOURNAL OF

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Single Numbers, 35 Cents. Yearly Subscription, $3.50

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THE AMERICAN GEOLOGIST, MINNEAPOLIS.

General European Agent, W. P. COLLINS, 157 Great Portland St., London W. Eng.

Entered at the Minneapolis post-office as second-class matter.

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For the year 1890 the GEOLOGIST *will continue to be issued at the subscription price of $3.50. The style and size will remain about the same as in the past. The editorial corps will be somewhat enlarged. The editors aim to make it a representative of the geology of America, and an important ally to teachers and investigators, as well as an essential to libraries. It will give a monthly digest of the current progress in geology in any and all parts of America. While devoted mainly and necessarily to the United States, it will embrace contributions from Canadian geologists, and will continue to review publications from all parts of the world.*

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